Geol Survey

STATE OF ILLINOIS
STATE GEOLOGICAL SURVEY
FRANK W. DEWOLF, Director

Cooperative Coal Mining Series
BULLETIN 18

TESTS ON CLAY MATERIALS

AVAILABLE IN

ILLINOIS COAL MINES

BY

R. T. STULL and R. K. HURSH
Ceramics Department, University of Illinois

ILLINOIS COAL MINING INVESTIGATIONS

Prepared under a cooperative agreement between the Illinois State Geological Survey, the Engineering Experiment Station of the University of Illinois, and the U. S. Bureau of Mines.

PRINTED BY AUTHORITY OF THE STATE OF ILLINOIS

ILLINOIS STATE GEOLOGICAL SURVEY
UNIVERSITY OF ILLINOIS
URBANA
1917

The Forty-seventh General Assembly of the State of Illinois, with a view of conserving the lives of the mine workers and the mineral resources of the State, authorized an investigation of the coal resources and mining practices of Illinois by the Department of Mining Engineering of the University of Illinois and the State Geological Survey in cooperation with the United States Bureau of Mines. A cooperative agreement was approved by the Secretary of the Interior and by representatives of the State of Illinois.

The direction of this investigation is vested in the Director of the United States Bureau of Mines, the Director of the State Geological Survey, and the Director, Engineering Experiment Station, University of Illinois, who jointly determined the methods to be employed in the conduct of the work and exercise general editorial supervision over the publication of the results, but each party to the agreement directs the work of its agents in carrying on the investigation thus mutually agreed on.

The reports of the investigation are issued in the form of bulletins, either by the State Geological Survey, the Engineering Experiment Station, University of Illinois, or the United States Bureau of Mines. For copies of the bulletins issued by the State Geological Survey, address State Geological Survey, Urbana, Illinois; for those issued by the Engineering Station, address Engineering Station, University of Illinois, Urbana, Illinois; and for those issued by the U. S. Bureau of Mines, address Director, U. S. Bureau of Mines, Washington, D. C. (See list [illegible] end of book.)

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TESTS ON CLAY MATERIALS AVAILABLE IN ILLINOIS COAL MINES

By R. T. Stull and R. K. Hursh

INTRODUCTION

During the progress of field work under a cooperative agreement between the State Geological Survey, the U. S. Bureau of Mines, and the Engineering Experiment Station of the University of Illinois, it was decided to determine the possibility of using in the clay-working industry floor clays and roof shales from Illinois coal mines. Arrangements were made by which the Geological Survey would furnish the samples and the Department of Ceramic Engineering[1], University of Illinois, would make the necessary physical and burning tests.

During the first season, the collection of samples was made incidental to the regular field work of the geologists, and some actual sampling was done by the mining companies. Twenty-three samples were collected and tested during the winter of 1912-13 and designated as Group 1. The desirability of systematic sampling was recognized, and during the summer of 1913 one man's entire attention was given to this work. Eighty-three samples were collected, and in this report they are designated as Group II. The tests on this series were similar to those for Group I, but more efficient means were devised during the second season for grinding and molding the material.

By way of summary it may be said that 49 samples proved to be worthless, 5 were of questionable value, and 52 were found adapted to the manufacture of a number of clay products. Common brick can be made from the material represented by 52 counties; 39 were usable for front brick; 29 for hollow ware; 6 for paving brick; 6 for fireproofing; 1 for enameled brick and terra cotta; 2 for stoneware and sewer pipe and 2 for No. 2 fire brick. These materials were not from existing clay pits or clay mines, but from coal mines, where clay materials are not now utilized.

Before considering the results, it is desirable to give attention to the general factors that control the availability of clays and shales as successful ceramic materials.

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[1]The Graduate School of the University of Illinois cooperated by contributing money to be used in connection with the tests.

GENERAL CONSIDERATIONS

Cost of Plant

Under most favorable conditions of low cost of raw material and labor, it is not advisable to install a modern brick plant equipped with a permanent dryer and kilns for a daily capacity of less than 10,000 to 15,000 brick. An exception to this is made where the clay produces a high-grade product commanding a high market price. The cost of building a modern plant is a variable factor governed by local conditions and by the kind of material and equipment used in its construction. A well-known brick-works engineer has said that it requires approximately as many dollars to build a modern brick plant as is the daily capacity of the plant in bricks. It would, therefore, require approximately $15,000 to build a modern plant with a daily capacity of 15,000 brick. The rule is by no means rigid and may be regarded merely as an approximate guide.

Many clay-working enterprises have encountered serious troubles, and some have even failed due simply to the failure of making a thorough previous investigation of the clay, a very important step that should be assigned to a competent ceramic engineer or expert in order to determine quantity and quality of the material. Too often this is given minor consideration or is left in the hands of incompetents. It is not advisable to build a modern plant unless there is available sufficient clay of satisfactory quality to continue the plant in operation for a period of more than ten years. To make a thousand brick of standard American size requires approximately two cubic yards of clay. A plant making 15,000 brick per day would require 9,000 cubic yards, or approximately 13,500 tons of clay per year of 300 working days.

Importance of Systematic Field Examination

Since clays are not definite compounds, but are for the most part "mixtures of minerals", they may vary considerably in composition from point to point in the deposit. The composition may be very uniform horizontally over a considerable area, whereas the composition in a vertical direction is likely to show abrupt changes due to the manner in which the clay had been laid down, or to unconformities. Abrupt changes also occur horizontally where faulting is encountered.

Too much care can not be exercised in selecting the clay samples for tests. Fair average samples of the deposit should be taken at a number of places over the property. If two or more strata of different appearances occur, samples of these should be taken and tested sepa-

rately. Outcrops have been subjected to long periods of weathering and have been more or less purified by the breaking down of mineral matter and the leaching out of soluble salts by rains. The weathered portion of a shale will frequently give very good results under tests, whereas the inner unweathered shale may prove very troublesome. Since the weathered portion is only a negligible part of the deposit as a whole, it should be rejected in selecting the samples, and only the unweathered portions taken.

Importance of Laboratory Tests

It is a well-known fact that laboratory tests on small-sized samples do not furnish conclusive evidence as to the practical value of a clay for manufacturing purposes. The reason for this lies in the fact that factory conditions can not be duplicated in the laboratory. Nevertheless, the laboratory tests are essential in that they acquaint one with the physical behavior of clays and point out whether they have commercial possibilities or not. If a clay is so inherently bad as to be an impossible raw material for the manufacture of clay wares, this will be indicated by the laboratory tests. The laboratory tests will show also whether a clay is safe for making vitrified ware and will show to what class of products the clay is best suited.

If the laboratory tests indicate that a clay is capable of producing a desirable product without developing serious difficulties which might be encountered during the process of manufacture, then the results from the laboratory would warrant the further testing of the clay in a large enough quantity to approach factory conditions as closely as possible.

CHARACTERISTICS OF CLAYS FOR VARIOUS PRODUCTS

Common Brick

Common brick may be manufactured by either the soft-mud or the stiff-mud process—the former is best adapted to the rather plastic surface clays, whereas the latter process is most generally used in working shales. To produce a brick of satisfactory structure and appearance by the stiff-mud process requires a clay of an intermediate degree of plasticity. Short clays, or those of very low plasticity, have too little bonding strength in the stiff-mud condition to withstand the strains produced in passing through the die of the ordinary brick machine. The issuing column is likely to be rough or torn and frequently cracked. The ware is usually too fragile to be handled without breaking, and the dried body may crumble easily. Clays of very high plasticity will laminate and tear at the corner as the column issues from the die. Such materials usually produce a strong body

but show high-drying shrinkage, and the ware is likely to warp or crack unless dried very carefully.

Front Brick or Pavers

For front brick or pavers it is even more necessary that the clay be capable of forming a smooth column free from excessive lamination, and that it withstand the necessary handling both in the plastic and dried condition without breaking or crumbling. It must likewise dry safely without undue shrinkage and without warping or cracking.

Hollow Ware and Fireproofing

Clays for the manufacture of hollow ware and fireproofing must have a greater degree of plasticity than the minimum required for brick, in order that they may be molded properly. They must dry without cracking.

BEHAVIOR OF CLAYS DURING BURNING

General Discussion

Materials which possess satisfactory working and drying properties must next be judged upon the basis of their burning behavior. The effects of carbon in its various forms, pyrite, and ferrous iron in the oxidization and vitrification of clays will be discussed. Clays which may be oxidized easily require much shorter periods of burning than those which give greater difficulty. This is an important element in the cost of manufacture. Materials containing large amounts of carbon, pyrite, or ferrous iron or which become dense at low temperatures and therefore greatly retard the process of oxidization may be regarded as unsuitable for manufacturing purposes. The oxidization tests made in the present investigation show the comparative ease or difficulty of burning the various samples in this period and the relative danger of bloating due to incomplete oxidization. Clays that were completely oxidized in a few hours should give no great trouble in burning, but those that showed a black core of any considerable size at the end of the ten-hour period may be eliminated as commercial possibilities for any type of ware.

An exception may be noted in clays which remain quite porous at temperatures well above those usually used for oxidization and do not vitrify. In burning some materials of this sort, ground coal is actually added to the clay to aid in the burning of the ware. In such cases only porous common brick may be made.

Clays that crack or warp badly in burning can not be used for any ware save possibly common brick, but these should be discarded where any better material is available.

Pitting due to granules of iron compounds or due to the slaking of lime lumps in the burned clay when exposed to moist atmosphere is undesirable in any ware but does not eliminate a clay as a possibility for common brick and hollow ware unless it be excessive. Front brick and pavers must be sound and free from such defects.

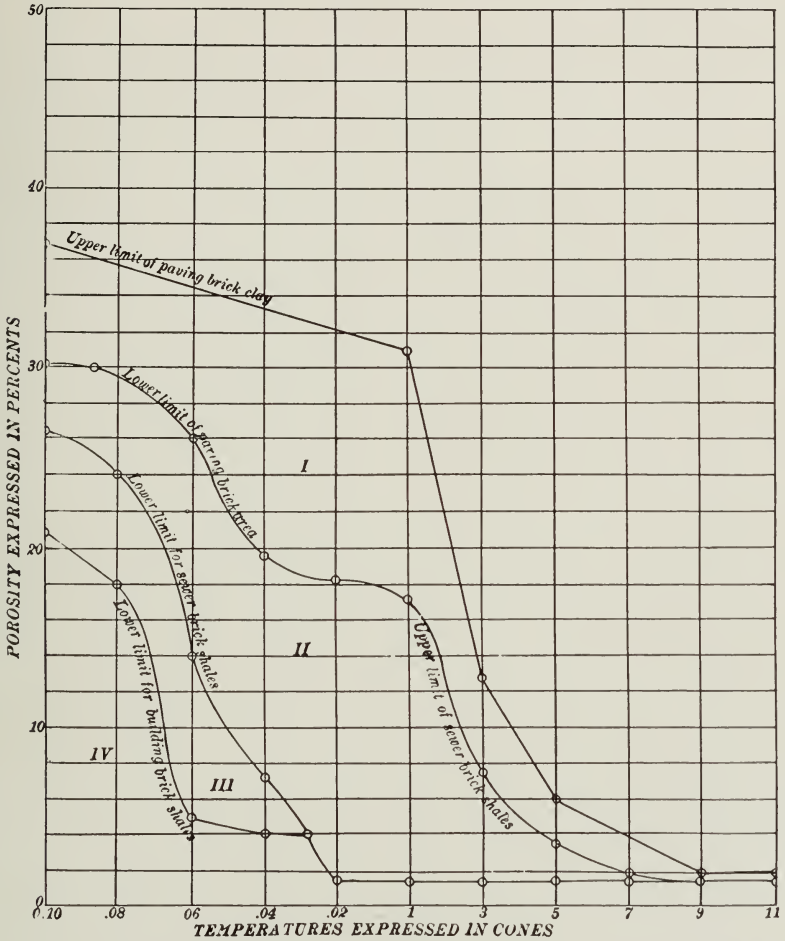

FIG. 1.—Curves showing changes in porosity of paving and building-brick clays with progressive intensity of heat treatment.

The most important criterion in determining the commercial availability of a clay lies in a proper interpretation of the porosity-temperature relation in burning. An excellent discussion of this has been given by Purdy.[2] The decrease in porosity indicates the progress of hardening and vitrification of the clay, the range of safe burning

[2]Purdy, Ross C., Paving brick and paving brick clays of Illinois: Ill. State Geol. Survey Bull. 9, 1908.

temperatures, and the point of overburning. It will be noted in the curves that many of the clays show an abrupt drop in porosity within a short range of burning temperature and a subsequent increase in porosity after the minimum has been reached. The rapid decrease in pore space is due to sudden fluxing action in the clay. The rise in the porosity curve indicates overburning and bloating. Where bloating quickly succeeds an abrupt drop in porosity, the material may not be safely used for vitrified wares, such as paving brick. The general shape of porosity temperature curves for various classes of brick has been shown by Purdy in figure 32.[2] It is noted that suitable paving-brick clays must not vitrify at too low a temperature and must have a sufficient range of burning temperatures at low porosity to permit proper burning within the limits of temperature difference in the commercial kiln, 2-4 cones. The ultimate criterion for this class of ware must be the toughness test, but the burning behavior test (fig. 1) serves to eliminate a majority of the undesirable materials.

Clays that will vitrify without serious danger of overburning but that are not suitable for first-class pavers will show porosity curves in Area II. These are suitable for vitrified front brick and hollow ware.

Clays having a short heat range and which overburn easily are found in Area III. These are suitable only for porous products such as common brick, unvitrified front brick, or porous hollow ware.

The materials showing porosity curves lying in Area IV should not be considered for manufacturing purposes, since they are likely to overburn and bloat even while very porous.

Color is not an important factor in common brick and hollow blocks and, to a minor degree only, in draintile. Paving brick are less salable if badly scummed by soluble sulphates. Front brick must be of good color and free from scumming ingredients. Scumming may be prevented, if not too serious, by the use of barium compounds, but where it showed excessively in a material in these tests the clay has not been considered available for front brick manufacture.

Summarizing the above remarks, we may list the following general requirements for the various wares:

Paving-brick clays should have a fair plasticity, should not laminate seriously, should dry safely and oxidize easily. They should not vitrify too easily and should show a good heat range at low porosity.

Front brick require clays of good molding and drying properties, easy of oxidation, of good color, and a fair range of burning temperature at which uniform colors can be obtained.

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[2]Purdy, Ross C., Paving brick and paving brick clays of Illinois: Ill. State Geol. Survey Bull. 9, 1908.

Common brick may be made from clays of fair plasticity and working properties if the drying behavior is good, if they oxidize in a reasonable length of time and produce a hard sound ware without too great danger of overburning.

The manufacture of *hollow ware* requires somewhat higher plasticity than would be necessary for brick, but other properties are about the same.

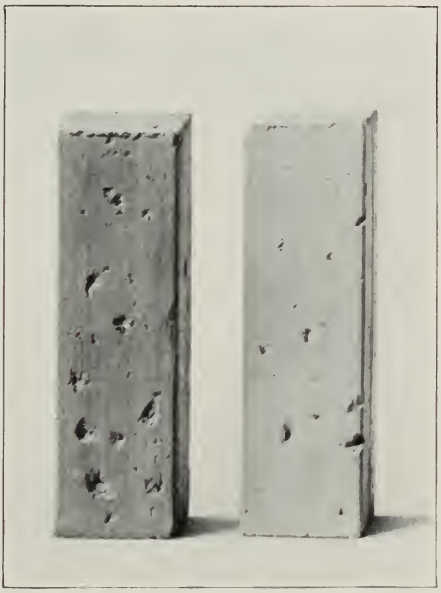

FIG. 2.—Briquets of a red shale (sample 50) and a bluff clay (sample 58) showing excessive surface pitting.

IMPORTANCE OF LONG HEAT RANGE

The differences in temperature between the hottest and coolest parts of a kiln are influenced by the design of the kiln and the manner in which it is fired and controlled. The differences in temperature within commercial kiln chambers have been found to vary from 20° C to as high as 80° C, or from one to four cones. For this reason it is essential that a clay should have a *long heat range,* so that ware from different parts of the kiln may be uniform in color, size, and density.

Lime, through its vigorous fluxing action when uniformly distributed, imparts to clay a short heat range. The temperature interval between vitrification and fusion is so short that it is dangerous to attempt the manufacture of a vitrified product from a calcareous clay. However, clays of this type may be valuable for the manufacture of

the more common porous products, such as common brick and hollow blocks.

Defects in Burned Ware

surface pitting

Surface pitting, or "popping out" as it is sometimes called, is caused by granules near the surface which expand and force out flat, irregularly shaped chips from the surface leaving the granules exposed (fig. 2). There are two distinct types of surface pitting. One kind occurs during the burning and is caused by granules of pyrite, iron carbonate, or fragments of concretions composed of a mixture of calcium and iron carbonates. The "popping out" is due to the peculiar expansion of these granules during the oxidation period and occurs at or below 700° C leaving a black hard grain exposed.

In a number of trials drawn from the kiln soon after popping occurred the black granules were strongly attracted by a magnet, indicating the presence of the magnetic oxide of iron (Fe_3O_4). If left in the kiln for a considerable period of time, they lost this property.

The second type of pitting does not occur until some time after the ware has been removed from the kiln and is due to the subsequent hydration and expansion of lime granules. The granules thus exposed are usually white and very friable.

Where surface pitting is profuse, it bars a clay as a desirable raw material for smooth-faced front brick, but would not be considered a serious defect in common brick or hollow ware.

scumming due to calcium sulphate in the clay

Approximately one part of calcium sulphate is soluble in 40 parts of water. When calcium sulphate is present in a clay either as such or in the form of gypsum, part of it is dissolved and is carried to the surface during drying and deposited as a "scum" or "efflorescence". The salt is comparatively stable and is practically unaffected during the burn and, unless the clay is burned hard enough to fuse it with the clay, causes a discolored or scummed product. Scumming if not excessive is not considered a serious defect, since it can be overcome by the addition of barium in the form of the carbonate, hydrate, chloride, or fluoride.

bloating due to overfiring

There are two different kinds of bloating. One kind is the result of improper oxidation as previously described. The second kind occurs after oxidation has been completed and is due to the evolution of occluded gases, to violatilization of some constituent of the

clay or to gas evolution caused by dissociation, as for example, the evolution of sulphur dioxide by the reduction and dissociation of a sulphate. In this condition the clay is said to be overfired (fig. 3). Bloating due to incomplete oxidation is characterized by a black spongy core with a light-colored, dense outer shell. In the case of overburning the color is generally uniformly gray, red, or brown, and the material is spongy throughout.

FIG. 3.—Briquets showing proper burning and overfiring.

There are three distinct types of bloating due to overfiring:[3]

1. Clays developing a vesicular structure when their normal porosities are still high and before vitrification begins.
2. Clays developing a vesicular structure simultaneously with the progress of vitrification.
3. Clays that do not develop a vesicular structure until more or less of a temperature interval has elapsed after they have become vitrified.

During the progress of burning clays, there is a decrease in porosity and an increase in shrinkage with rise in temperature after 900° C is passed. When bloating begins, there is an increase in porosity and a negative shrinkage or apparent increase in volume. In clays of the first type the point at which bloating begins is indicated by a change in the direction of the porosity curve. In clays of

[3]Bleininger, A. V., and Montgomery, E. T., Effect of overfiring upon the structure of clays: U. S. Bureau of Standards Tech. Paper 22, 1915.

the second and third types the pores developed by gas evolution are sealed due to vitrification, hence they can not be measured by saturation *in vacuo,* and no change in direction of the porosity curve is indicated. However, in all three types the point at which bloating begins is indicated by the change in direction of the shrinkage curve.

Clays of the first and second types are impossible raw materials for the manufacture of vitrified wares but may be valuable for the manufacture of porous products if burned at a safe limit below the point where bloating occurs. For a vitrified product it is essential that the clay should have a good *heat range* or temperature interval between the point at which it becomes vitrified and that at which it fails either by bloating or by fusion.

TESTS ON SAMPLES IN GROUP I

Process Employed

With few exceptions the workable shales are admirably adapted to the "stiff-mud" or plastic process of manufacture and are valuable raw materials for making structural materials such as building and paving brick, hollow blocks, draintile, sewer pipe, and a variety of similar products. The vast majority of shale brick are made by the stiff-mud process, and this is the only practicable process by which hollow blocks and pipe are made.

Accordingly the plastic process was employed in the following tests. In this work two groups comprising 108 different samples were tested. The work on the first group was nearly completed before the second group was received. The manner of testing the two groups was the same with the exception of a few changes which will be pointed out under Group II.

Group I comprised twenty-five samples; No. 24 from Galesburg and No. 25 from Streator are well-known shales which have been successfully employed for years in the manufacture of building and paving brick and were included for comparative purposes.

Preparation of the Samples

The samples, consisting of approximately 50 pounds each, were examined to detect the presence of gypsum, pyrite, carbonaceous matter, and carbonates of iron and lime. A two-pound representative sample was set aside for future reference, and the remainder reduced in a jaw crusher, passed through the ten-mesh screen and thoroughly mixed ready for tempering and molding the briquets.

Slaking

Many shales and fire clays possess the property of slaking in water. Some slake rapidly and yield a fine-grained plastic mass with

very little or no granular residue. Most of these are soft or of medium hardness, rather fine grained, very plastic and mold readily in either a dry or lubricated die. They generally show a high drying shrinkage and may warp or even crack in drying.

Another class of shales is medium hard to hard; these slake slowly to a mixture of coarse granular material with a more or less fine plastic portion. In general they show medium to good plasticity, mold without serious trouble, show a moderate drying shrinkage, and dry safely.

A third class is more or less hard, coarse, somewhat granular, perhaps sandy, and may contain numerous mica flakes and shell fossils. Shales of this class do not slake appreciably and show indifference to disintegration on weathering. When ground and tempered they show poor plasticity, mold with difficulty in the die, have very low drying shrinkage, and dry safely. When a plastic clay or shale is added to them, they frequently produce most excellent ware.

In order to obtain an approximate idea of the slaking behavior of the shales under tests, a 100-gram sample of each was weighed from the 2-pound sample, rejecting all fragments less than one-fourth inch in diameter. This was dried at 60° C for ten hours, placed in a granite pan and covered with distilled water, and the rate of slaking at room temperature observed at intervals over a period of 7 days. The observations were made every hour for the first five hours, then every two hours for the next ten hours, and finally every twelve hours to the end of the period.

Molding the Briquets

The ground and screened samples were prepared for molding the briquets by kneading and wedging the samples with sufficient water added to give best working plasticity. The samples after tempering were placed in a moist chamber for 24 hours to produce uniformity of moisture content. Briquets of two different sizes were made. For oxidation tests, trials 1¾″ x 1¾″ x 3½″ were hand molded and repressed. For determining tempering water, volume shrinkage, linear drying and burning shrinkages, porosity, tempering range, and color, briquets 1″x 1″x 3½″ were also hand molded and repressed. All briquets were dried in the open air at room temperature (about 70° F).

Oxidation Tests

During the process of burning red and buff clays, it is necessary to burn out the carbon and sulphur and to convert the ferrous iron to the ferric form before the temperature can be raised safely and the ware vitrified. This process is called *oxidation* and should be carried

out within a temperature interval in which the ware is at its maximum porosity so as to allow the ingress of oxygen from the kiln atmosphere and the egress of gases due to distillation and combustion. If the temperature of the kiln is raised to the vitrification stage before oxidation is complete, a black-cored or even bloated product will be the result.

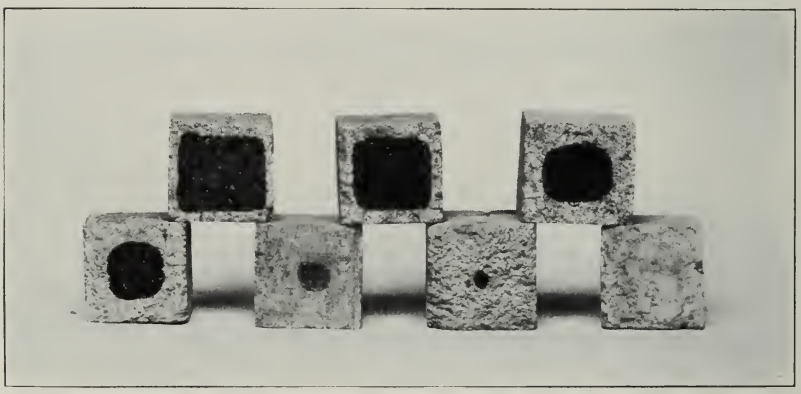

FIG. 4.—A clay high in pyrite and carbon showing progress of diminishing black core during oxidation. The trials were drawn from the kiln at one-hour intervals.

Under practical working conditions it has been found that the best range in which to hold the kiln until oxidation is complete lies between 600° C and 900° C.[4] The most troublesome materials during oxidation are bituminous matter, sulphur in the form of pyrite, ferrous oxide, and ferrous carbonate. As long as any carbon or combustible sulphur is present, the iron remains in the ferrous form and is evidenced by the resulting black core surrounded by an oxidized outer shell of light salmon or buff color (fig. 4).

According to Wells[5] pyrite is dissociated at two different temperatures one molecule of sulphur coming off at 400° C, and the second remaining until about 900° C. In the tests of the following shales it was observed that the pyrite could be completely dissociated and the iron converted to the ferric form if the temperature of the kiln were held long enough at 650° C. However, the rate of oxidation increases rapidly with increase of temperature so long as the clay remains sufficiently porous to allow the reaction to go on freely.

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[4]Orton, E., The role played by iron in the burning of clay: Trans. Am. Cer. Soc. vol. 5, p. 404, 1903.

[5]Wells, H. B., A method of overcoming the sulphur problem: Trans. Am. Cer. Soc. vol. 11, p. 94, 1909.

Many "Coal Measures" shales are high in sulphur and bituminous matter. Commonly they contain as much as 4 per cent of bituminous matter and 2 per cent of pyrite. The average periodic brick kiln holds approximately 100,000 American-size brick. The average weight per thousand dry brick is 3 tons. In 15 pounds of pyrite are 7 pounds of iron and 8 pounds of sulphur. If a shale contains 4 per cent of bituminous matter and 2 per cent of pyrite, a kiln holding 100,000 brick made from the shale would contain 12 tons of fuel as "coaly matter" and over 3 tons as combustible sulphur.

If a shale of this character vitrifies at a comparatively low temperature, it becomes a very troublesome, if not a disastrous material to handle. When the temperature of the kiln rises to the ignition point, the volatile gases take fire on the exposed surfaces of the brick and raise the temperature rapidly. The sudden rise in temperature vitrifies the outside shell of the brick, closes the pores, prevents the escape of gases, and causes bloating not unlike the resulting action of yeast in bread.

In order to prevent bloating it is necessary to hold the temperature of the kiln down to a safe limit below the vitrification temperature until the combustible matter has been eliminated. Orton[6] recommends a method of kiln control which has proved very effective. Briefly it consists of the following:

If a clay is rather refractory and remains porous at a comparatively high temperature, the evolution and combustion of the volatile matter may progress without causing serious trouble.

1. Fire the kiln normally until the evolving gases ignite. This is indicated by a sudden brightening or glow in the kiln chamber.
2. At this point, draw the fires, lower the damper, and seal up the fire boxes and kiln to exclude air and to allow the evolution of the gases to progress slowly without increasing the temperature.
3. As soon as the danger is passed the "glow" will diminish and the kiln temperature drop. At this point, raise the damper, open the fire boxes, and proceed with the firing normally.

To obtain a comparison of the oxidizing behaviors of the different clay samples the following oxidation test was made. Briquets were placed in a down-draft kiln, the temperature raised gradually to 650° C, and held constant. As soon as this temperature was attained a trial piece of each clay was drawn and further specimens were drawn every hour for a period of 9 hours. As soon as the trials were taken from the kiln they were covered with sand, allowed to cool and the areas of the oxidized part and the black core of a cross-section measured with a planimeter. (See figure 1 and time-rate oxidation curves.)

[6]Op. cit., pp. 395-396.

Tempering Water

When water is added to clay, the mass increases in volume, and on drying a corresponding shrinkage takes place. The amount of water[7] necessary to add to a clay in order to make it sufficiently plastic for molding varies with different clays. The higher the plasticity and the finer the grain, the more water is required to temper a clay in order to make it "moldable" and the greater is the shrinkage on drying. The amount of water required to temper a clay to the proper consistency for molding was determined by taking the weight of five freshly molded briquets, drying them at 100° C, cooling, and weighing. The percentage of water required, based upon the dry weight of the clay, is calculated from the following formula:

$$\frac{A - B}{B} \times 100 = \%\ \text{tempering water},$$

Where: A = weight of freshly made briquet,
B = weight of dry briquet.

Linear Drying Shrinkage

The linear drying shrinkage was determined by measuring the freshly molded briquet with Vernier calipers and again measuring after drying. The percentage of linear drying shrinkage based upon dry length was calculated from the following formula:

$$\frac{L_1 - L_2}{L_2} \times 100 = \%\ \text{linear drying shrinkage},$$

Where: L_1 = molded length,
L_2 = dry length.

Volume Shrinkage

The volume shrinkage in drying was determined by the kerosene oil immersion method, using a modification of the Seger volumeter and the calculations were made according to the formula:

$$\frac{V_1 - V_2}{V_2} \times 100 = \%\ \text{volume shrinkage}.$$

Where: V_1 = volume of freshly molded briquet,
V_2 = volume of the briquet dried at 100° C.

Burning

Since a number of the shales are very fine grained and contain carbonaceous matter and pyrite, they are slow and difficult to oxidize. To insure thorough oxidation of the trials and to save time in the subsequent burns, all burning trials were first placed in the kiln,

[7]Sometimes erroneously called "water of plasticity."

oxidized at 650° C for fifteen hours and allowed to cool slowly in a clear atmosphere.

To determine the porosity, fire shrinkage, heat range, and color, nine separate burns were made using pyrometric cones as the temperature indicators.[8]

These burns were made at cones 010, 08, 06, 04, 03, 02, 01, 1, 2, and 3. Three briquets of each shale, oxidized as previously described, were placed in each burn and the average measurements of these taken as the data for plotting the curves. The firing was done under oxidizing conditions following a straight line time-temperature curve.

Burning Shrinkage

This was calculated for the three briquets in each burn on the dry length as basis and is equal to

$$\frac{\text{average loss in length}}{\text{average dry length}} \times 100.$$

Porosity

The burned briquets were weighed dry, immersed in water for 24 hours, then placed under water *in vacuo* for 24 hours (fig. 5). The saturated weights and suspended weights were determined and the porosities calculated from the formula

$$\frac{W - D}{W - S} \times 100 = \%\ \text{porosity}$$

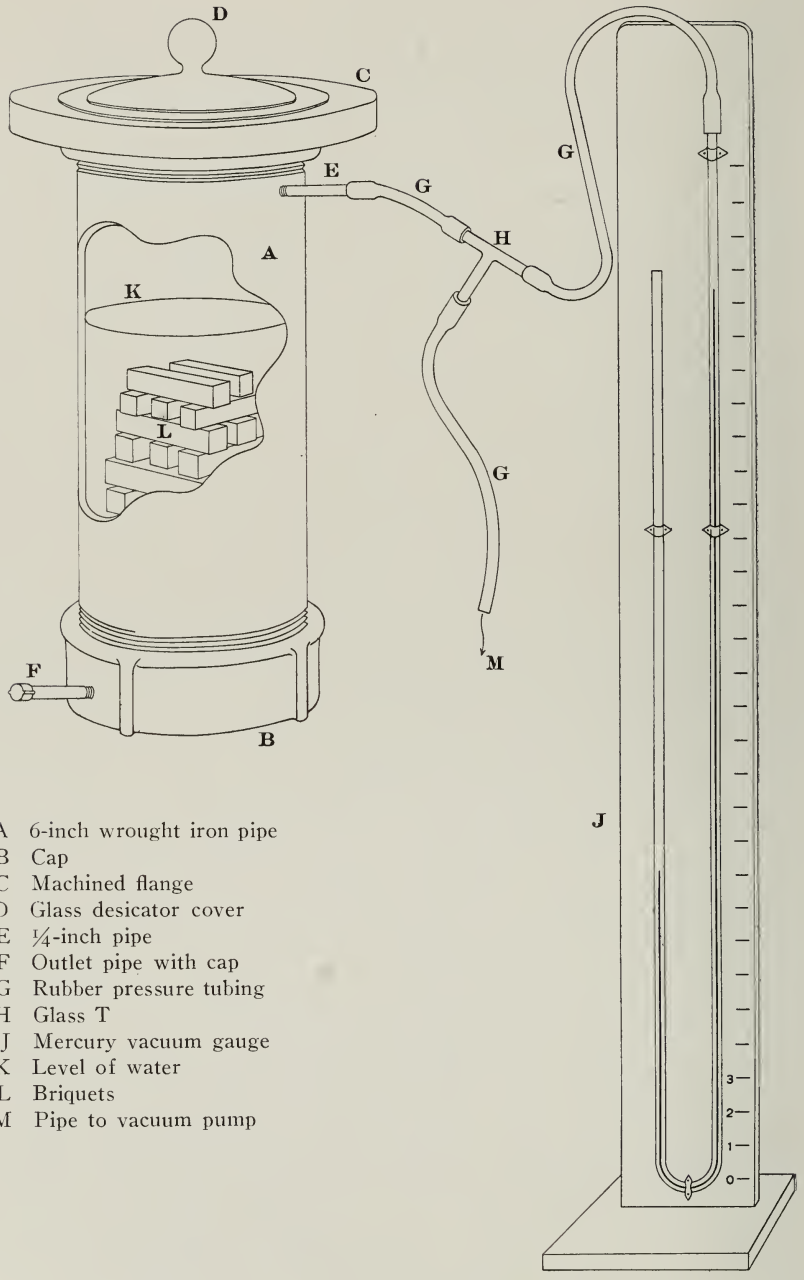
Where: W = saturated weight,
D = dry weight,
S = weight suspended in water

TESTS ON SAMPLES IN GROUP II

Group II contains 83 different samples, including Nos. 26 to 108. In testing so large a number it was obvious from the experience gained in Group I that it would be necessary to save time and expense by devising more efficient means for preparing the samples and molding the briquets.

[8]Owing to the erratic behavior of cones, more consistent results are obtainable by using a pyrometer as the temperature indicator, and making all burns according to a definite time-temperature curve after passing the oxidation period. The indicated temperatures in Centigrade for these cones are:

Cone	010	08	06	04	03	02	01	1	2	3
Temperature degrees Centigrade	950	990	1030	1970	1090	1110	1130	1150	1170	1190



A 6-inch wrought iron pipe
B Cap
C Machined flange
D Glass desicator cover
E ¼-inch pipe
F Outlet pipe with cap
G Rubber pressure tubing
H Glass T
J Mercury vacuum gauge
K Level of water
L Briquets
M Pipe to vacuum pump

FIG. 5.—Apparatus for saturating briquets *in vacuo*.

Grinding the Samples

The samples were ground in a 5-foot dry pan provided with perforated plates with one-tenth-inch slots. A circular sheet-iron pan provided with a slot 5 inches wide running from the center to the circumference was bolted to the frame 6 inches below the grinding pan. Heavy brushes were attached to the under side of the dry pan and revolved with it sweeping over the inner surface of the sheet-iron pan. The dry pan was set in motion and the clay sample of approximately 45 to 50 pounds introduced. As fast as the material became crushed and passed through the one-tenth-inch perforation, it

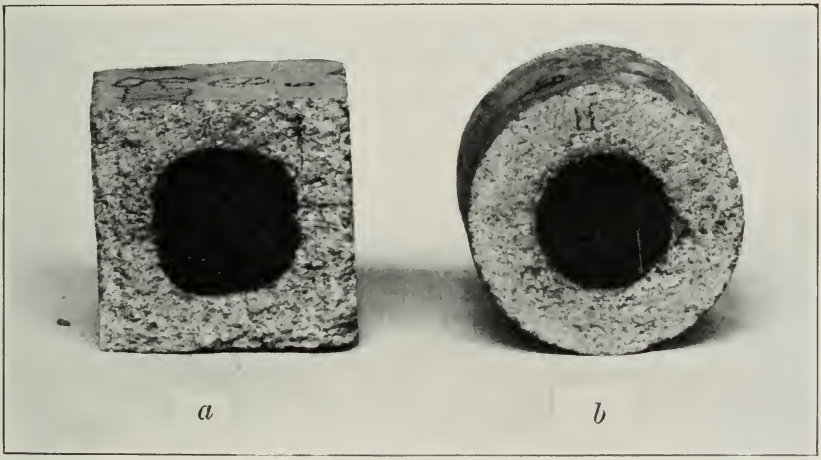
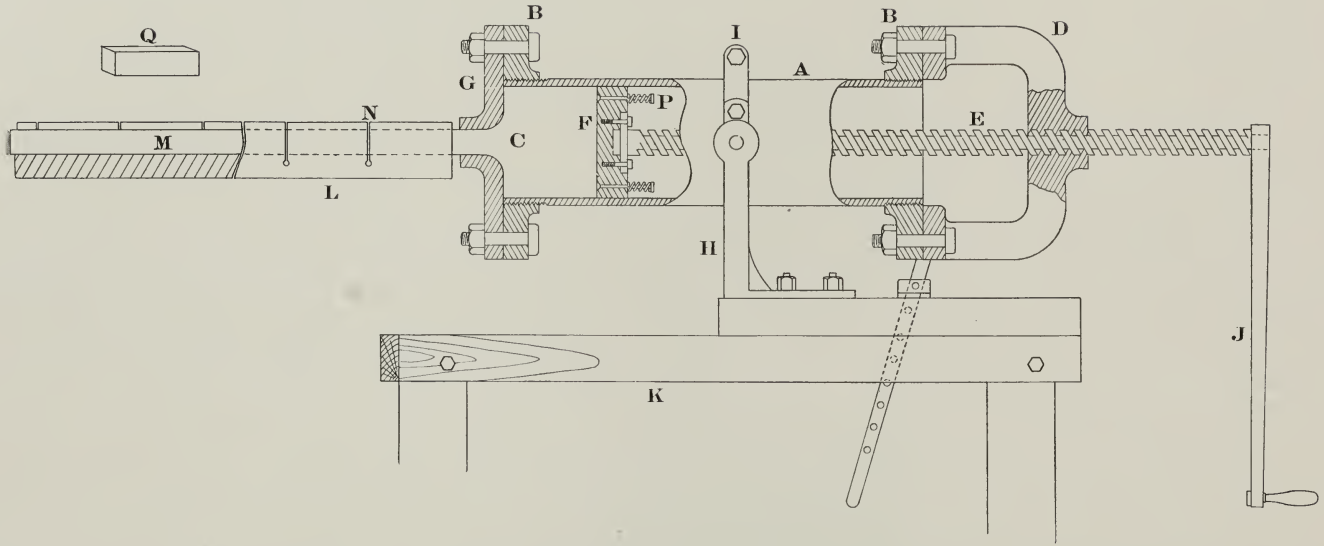


Fig. 6.—*a*, oxidizing briquet from Group I showing black core approaching the circular form; *b*, oxidizing cylinder from Group II.

fell into the sheet-iron pan and was swept around and out of the 5-inch slot where it was collected and passed through a ten-mesh screen; the tailings thrown back into the dry pan. By this arrangement the pan became thoroughly and automatically cleaned ready for the next sample. The time required to prepare a sample was approximately 20 to 30 minutes.

Molding the Briquets

In Group I the oxidation trials were made in the form of parallelopipeds 1¾″ x 1¾″ x 3½″. Oxidation progresses faster at the edges than through the sides, as shown in sample *a*, figure 6. As oxidation progresses, the black core of a cross-section approaches more and more the circular form. In order to eliminate the error and thereby obtain more accurate data as to the rate of oxidation,



A	5-inch standard pipe, machined	E	Square tread screw	I	Strap	M	Clay Column
B	Pipe flanges	F	Piston plate	J	Crank	N	Cutting slots
C	Clay	G	Die	K	Table	P	Pin and spring
D	Yoke	H	Stand	L	Cutting box	Q	Briquet as cut, 1″ x1″ x 3½″

FIG. 7.—Hand plunger machine for molding briquets.

the oxidation trials in Group II were made cylindrical in form, 1¾" diameter by 3½" long (fig. 6).

In order to eliminate the "personal factor" entering into hand molding, as well as to introduce the time-saving element, the oxidation cylinders and the burning briquets were molded stiff-mud in a hand plunger machine (fig. 7) constructed especially for the purpose. The machine was provided with two interchangeable dies—one with a cylindrical opening for molding the oxidation cylinders, and the other with an opening one inch square for molding the briquets for the burning tests.

The clay sample tempered with water to the proper molding consistency was placed in the cylinder of the machine and a continuous bar or column of the clay made to issue by turning the crank. The column passed from the die into a cutting box where it was cut into 3½-inch lengths by a No. 26 B. & S. gage wire bow. The briquets were not repressed.

Screening Test

The slaking test was carried out the same as that described under Group I and the slaked material passed through the following Tyler Standard Screens.

Screen mesh	Size opening *Inches*	Size opening *Millimeters*
10	.0650	1.651
20	.0328	.833
35	.0164	.417
65	.0082	.208
100	.0058	.147
150	.0041	.104

Burning

The burning was done in the same manner as in Group I with the exception that two higher burns were added, cone 4 or 1210° C, and cone 5 or 1230° C.

Barring the above mentioned changes, the remainder of the work was carried out in accordance with the methods described under Group I.

RESULTS OF THE TESTS

The data from the tests of the various samples are presented at the end of the book accompanied by curves showing the burning behavior of the clays. For the sake of convenience the curves representing time-rate of oxidation, shrinkage-temperature, and porosity-

temperature for each shale are plotted on one sheet. In the time-rate oxidation curves, the percentage oxidized areas are plotted on the ordinate and time on the abscissa[9]. The porosities and shrinkages are plotted on the ordinate and the temperatures, expressed on cones, on the abscissa. The porosity scale is indicated at the left and the shrinkage scale (twice the magnitude of the porosity scale) at the right of the diagram.

Where several samples have been taken from the same mine or from adjacent points and curves have been plotted on the same sheet as far as possible. As a matter of convenience for reference and comparison of clays from the same general locality, the data sheets and curves have been arranged in groups corresponding to the various coal districts of the State (fig. 8). Within these districts the samples have been further arranged alphabetically by counties and by towns.

More or less similarity may be noted in the characteristics of the roof shales from a given district, especially in regard to their burning behavior. The plastic properties and the general molding and drying behavior of the materials seem to be determined largely by the local conditions during or subsequent to their deposition. The constitution, as evidenced by the fluxing action during burning and the porosity-temperature relation seems to be quite similar in samples over a large area. The properties of the floor materials show much greater variation even within relatively small areas.

District No. 1.—Samples were taken from mines at Coal City, Wilmington, Seneca, La Salle, Black Hollow, Oglesby, Wenona, Cherry, Spring Valley, Minonk, and Sparland. With the exception of the samples from Wenona the roof shales of the district show considerable similarity in their burning behavior. They vitrify at comparatively low temperatures, show a short heat range in burning, and overburn easily. As has been shown these characteristics eliminate them as possibilities for the manufacture of vitrified wares such as paving brick. They may be used for more or less porous products such as common brick, front brick, and hollow ware in case the molding and drying properties are satisfactory. Common brick requires sufficient degree of plasticity to permit molding by the stiff-mud process. For hollow ware the same qualification may be made, but the plasticity must be greater than for brick, and a greater strength is required in the dried body. For front brick there must be, in addition to satisfactory molding and drying behavior, a desirable color.

[9]Purdy, R. C. and Moore, J. K., Pyro-physical and chemical behavior of clays: Trans. Am. Cer. Soc. vol. 9, p. 211, 1907.

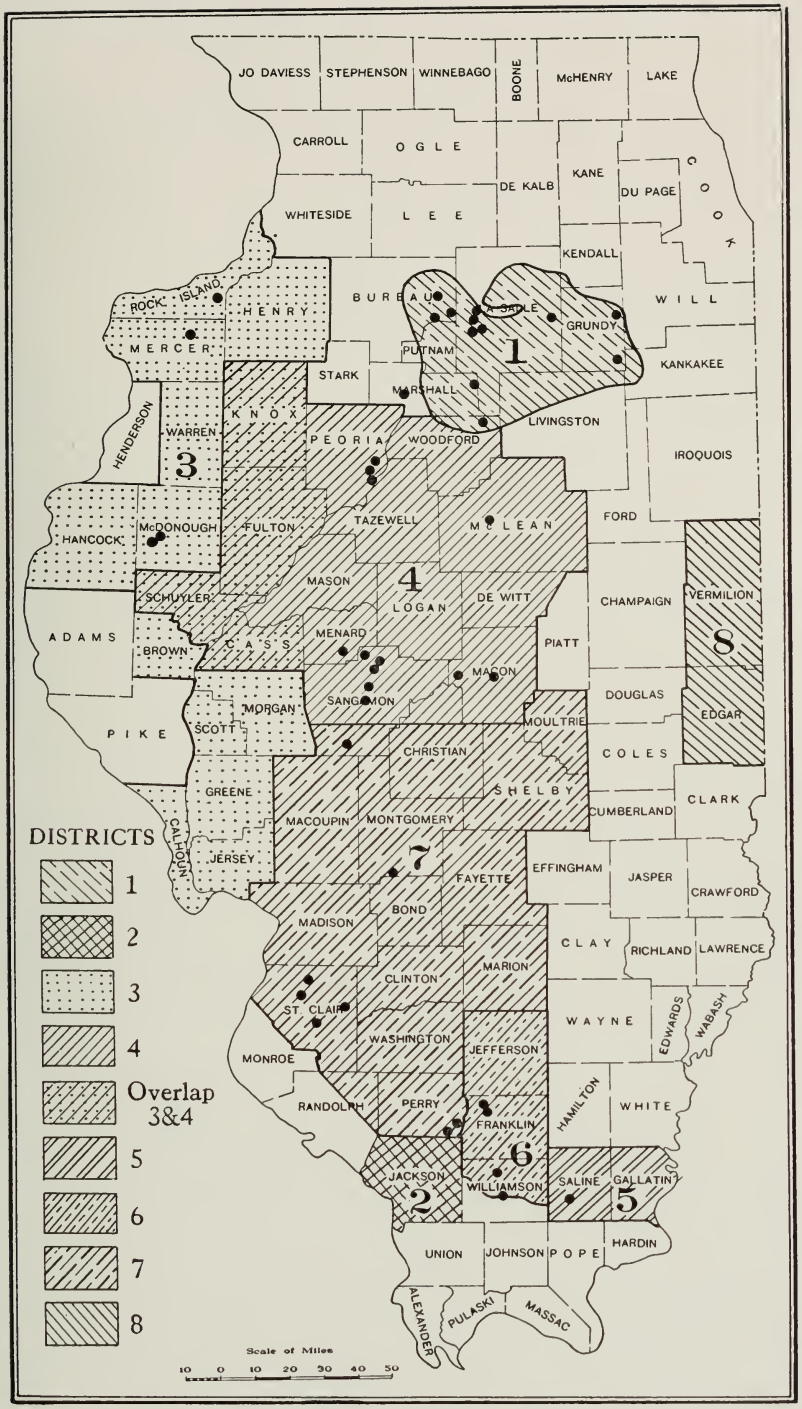


FIG. 8.—Map showing division of State into districts and location of samples tested.

The color is determined largely by the presence or absence of soluble salts, such as sulphates, and depends entirely on the local conditions of the deposit.

District No. 3.—Only one sample of roof material was taken from this district. Floor materials from Coal Valley, Matherville and Colchester were quite sandy and very different in character from the well-known Colchester clay in McDonough County.

District No. 4.—Samples were obtained from Peoria, South Bartonville, Bloomington, Athens, Decatur, Niantic, Cantrall, Selbytown, Sherman, and Springfield. Few of the materials from the district are suitable for manufacturing purposes. Nearly all the floor materials contain considerable amounts of bituminous matter and give great trouble in oxidation. Most of the clays crack in burning, have a very short heat range, and overburn easily.

District No. 5.—Only two samples were tested, a roof shale and a floor clay from the mine of Saline County Coal Company at Harrisburg.

District No. 6.—Samples of floor materials from Sesser, Rend, Herrin, and Marion, and a roof material from Rend were tested. Of these, the floor material from Sesser and the roof shale at Rend are the only suitable clays for manufacturing purposes.

District No. 7.—Samples of floor material were taken at Panama, Auburn, Mascoutah, Belleville, Freeburg, and O'Fallon, and two samples of roof materials at Duquoin. The floor clays in the district, as represented in these tests, overburn readily before reaching vitrification. Most of the samples were unsuitable for manufacturing purposes, due to their short heat range and tendency to crack in burning. The roof shale from Duquoin and the floor clay from Auburn are promising clays for manufacturing purposes.

ILLINOIS ROOF SHALES AND FLOOR CLAYS

The following notes concerning floor clays and roof shales in Illinois coal mines were tabulated for a recent Survey publication[10] and are reprinted here as a convenient reference to general roof and floor characteristics in the various districts.

[10]Young, L. E., Surface subsidence in Illinois resulting from coal mining: Illinois Coal Mining Investigations Bull. 17, p. 24, 1916.

Character of roof and floor of the commercial coal beds throughout Illinois

District I

Coal bed	Roof	Floor
No. 2	Gray shale, replaced in places by a black shale about 3 feet thick.	Dark-gray fire clay up to several feet thick. In some parts of the La Salle field a hard sandstone lies directly beneath the coal.
No. 5	Varies from a gray shale to black "slate", sandstone and locally limestone; "white top" roof in certain areas.	Gray fire clay 1 to 4 feet thick, underlain by sandstone or sandy shale.
No. 7	Gray silicious shale 35 or more feet thick. Immediate roof is generally darker than the upper beds of shale.	Gray fire clay 2 to 3 feet thick lying on sandstone. Black shale in places forms the floor.

District III

No. 1	In Mercer and Rock Island counties, hard black shale 2 to 5 inches thick; limestone cap rock, 1 to 4 feet.	Light gray micaceous fire clay which heaves badly when wet. In places an irregular band (3 to 6 inches) of carbonaceous shale or sandstone lies immediately below the coal.
No. 2	Hard black shale generally not over 1 foot thick, overlain by a limestone cap rock 3 feet thick.	Gray fire clay containing nodules of iron pyrites.

District IV

No. 5	Black sheety shale up to 35 feet thick. A limestone cap rock over the shale. Where shale is thin, the cap rock becomes the roof.	Gray fire clay.

District V

No. 5	Light gray to black shale, in some areas laminated with coal for a distance of 3 feet above seam. Shale of immediate roof is weak.	Fire clay generally. In some areas the clay is sandy and heaves badly when wet.

Character of roof and floor of the commercial coal beds throughout Illinois
(Concluded)

District VI

Coal Bed	Roof	Floor
No. 6 in: *Franklin*	Coal is left as immediate roof. Upon the coal is a thin bed of draw slate, and within 25 feet above the coal is usually a limestone cap rock 4 to 10 feet thick.	Gray fire clay 2 to 8 feet thick underlain by a sandy limestone. Heaves in only a few mines.
Williamson	Coal is left generally as roof. In a number of mines the limestone cap rock is missing or higher than in Franklin County.	Gray fire clay 2 to 4 feet thick underlain by limestone. The floor heaves badly in several mines.
District VII		
No. 6 in: *Clinton*	Limestone cap rock, 5 to 15 feet thick. In places black shale between limestone and coal.	Clay, 18 inches to 8 feet in most places on shale.
Christian	Black shale overlain by limestone ranging from 1 to 20 feet. In some mines shale between coal and limestone.	Clay of variable thickness.
Macoupin	Black shale with limestone cap rock.	Clay averaging about 1 foot. Beneath the clay there is generally limestone.
Madison	Gray or black shale of varying thickness overlain by limestone ranging in thickness from a few feet to as much as 30 feet. In some places limestone rests on the coal.	
Marion	Limestone cap rock, about 15 feet thick.	Clay of varying thickness.
Montgomery	Limestone cap rock.	Clay of variable thickness.
St. Clair	Black shale and limestone.	Thin clay on limestone.
Perry, Randolph, and Washington	Black shale under limestone to the west of Duquoin anticline. To the east, the same limestone, if present at all,[a] is 100 feet above coal.	Clay of variable thickness.
Shelby and Moultrie	Shale and limestone.	Shale, clay, limestone.
Sangamon	Irregular shale and limestone.	Thin clay.

[a]Cady, G. H., Coal resources of District VI: Ill. State Geol. Survey Coal Mining series Bull. 15, 1916.

RESULTS OF LABORATORY TESTS OF SAMPLES

In the following pages, each sample is described, and the results of burning tests are shown by means of diagrams. For a complete list of mines from which samples were taken, the reader should refer to the table on pages 34 and 35.

Index list of mines in which samples were collected and tested

District, county, and company	Mine name or number	Town location	Material tested	Description of tests
				Page
District I—				
Bureau County—				
St. Paul Coal Company	No. 2	Cherry	Roof	39
Spring Valley Coal Company	No. 5	Dalzell	Roof and floor	41
Marquette Third Vein Coal Company	Marquette	Marquette	Roof and floor	44
Grundy County—				
Big Four Wilmington Coal Company	No. 6	Coal City	Roof and floor	47
Chicago Wilmington & Vermilion Coal Co	No. 1	South Wilmington	Roof and floor	49
La Salle County—				
La Salle County Carbon Coal Company	La Salle shaft	La Salle	Roof and floor	53
Matthiessen & Hegeler Zinc Company	M. & H.	La Salle	Roof and floor	56
Illinois Zinc Company	Black Hollow	Oglesby	Roof and floor	57
Oglesby Coal Company	Oglesby	Oglesby	Floor	60
Gray & Jones Coal Company	G. & J.	Seneca	Roof and floor	60
Marshall County—				
Illinois Valley Coal Company	No. 1	Sparland	Roof and floor	65
Wenona Coal Company	Wenona	Wenona	Roof and floor	68
Woodford County—				
Minonk Coal Company	No. 2	Minonk	Roof and floor	71
District III—				
McDonough County—				
Colchester Coal & Manufacturing Co	.....	Colchester	Roof	73
Valentine Farm Mine	.....	Colchester	Floor	73
Mercer County—				
Alden Coal Company	No. 7	Matherville	Floor	75
Rock Island County—				
Pryce Coal Company	.....	Coal Valley	Floor	79
District IV—				
Macon County—				
Manufacturers & Consumers Coal Co	No. 1	Decatur	Roof and floor	83
Decatur Coal Company	Niantic	Niantic	Floor	86
McLean County—				
McLean County Coal Company	McLean	Bloomington	Roof and floor	87

Menard County—				
Wabash Coal Company	No. 2	Athens	Floor	91
Peoria County—				
Clark Coal & Coke Company	No. 2	Peoria	Floor	93
Crescent Coal Company	No. 1	Peoria	Floor	95
Colliers Cooperative Coal Company	No. 1	South Bartonville	Floor	97
Sangamon County—				
Cantrall Cooperative Company	Cantrall	Cantrall	Roof	99
Williamsville Coal Company	.....	Selbytown	Floor	101
Illinois Midland Coal Company	.....	Sherman	Floor	103
Montour Coal Company	No. 400	Springfield	Floor	105
Springfield District Coal Mining Co.	No. 5	Springfield	Floor	107
District V—				
Saline County—				
Saline County Coal Company	No. 2	Harrisburg	Roof and floor	111
District VI—				
Franklin County—				
W. P. Rend Collieries Company	No. 1	Rend	Roof and floor	112
Sesser Coal Company	Sesser	Sesser	Floor	115
Williamson County—				
Carterville & Herrin Coal Company	Jeffrey	Herrin	Floor	115
Brinkley & Miles	.....	Marion	Floor	117
District VII—				
Montgomery County—				
Shoal Creek Coal Company	No. 1	Panama	Floor	119
Perry County—				
Brilliant Coal Company	Horn	Duquoin	Roof	119
Paradise Coal Company	Paradise	Duquoin	Roof	121
St. Clair County—				
Pioneer Coal Company	.....	Belleville	Floor	121
Mulberry Hill Coal Company	No. 2	Freeburg	Floor	123
Kolb Coal Company	No. 2	Mascoutah	Floor	123
Joseph Taylor Coal Company	Taylor	O'Fallon	Floor	126
Sangamon County—				
Auburn & Alton Coal Company	A. & A.	Auburn	Floor	126

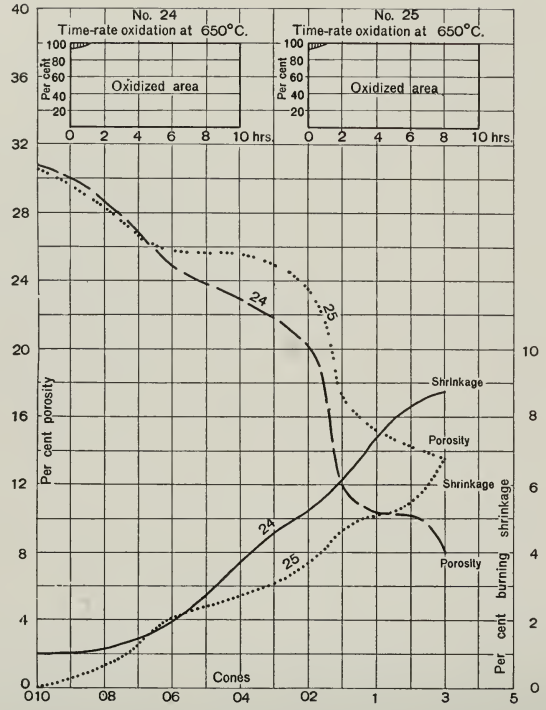


FIG. 9—Graphic illustration of the laboratory tests of Samples 24 and 25, shales used by the Barr Brick Company, Streator, and by the Burlington Paving Brick Company, Galesburg.

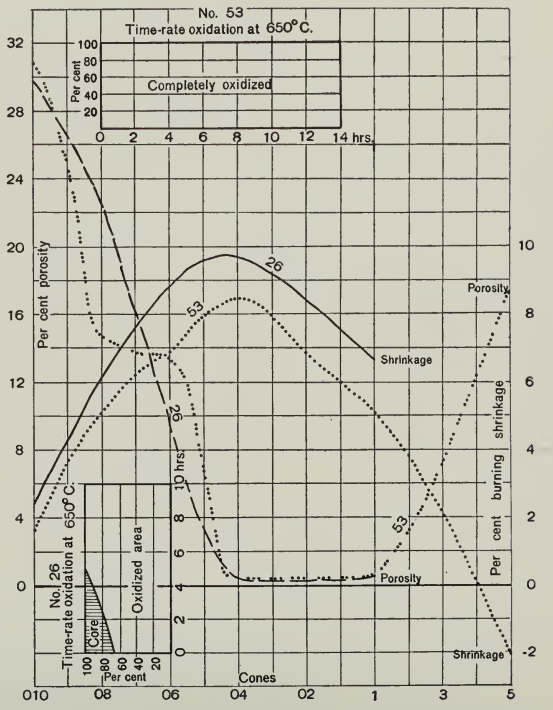


FIG. 10—Graphic illustration of the laboratory tests of Samples 26 and 53, roof materials of coal No. 2 used by Illinois Clay Company, Oglesby.

BARR BRICK COMPANY, STREATOR

(See figure 9)

Sample 25.—Dark, slate-gray shale of medium hardness; contains gypsum, sample comparatively free from carbonaceous matter and concretions.

No slaking and screening tests made.

Plasticity	Fair
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	4.71%
Volume drying shrinkage	15.77%
Tempering water	22.17%
Oxidation	Complete in 1 hour.
Maximum safe burning temperature	Above cone 3.
Heat range	Temperature not carried high enough to determine this.
When burned at cone 3—	
Burning shrinkage	6.82%
Total shrinkage	11.53%
Porosity	13.70%
Fracture	Stony
Color	Dark red; scums badly.
Possibilities	Common, front, and paving brick, hollow ware.
Precautions	For front brick barium salt should be added to overcome scumming.

BURLINGTON PAVING BRICK COMPANY, GALESBURG

(See figure 9)

Sample 24.—Blue-gray shale, somewhat sandy, shows a trace of calcium sulphate, otherwise sample seems to be quite uniform.

No slaking or screening tests made.

Plasticity	Fair
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	5.54%
Tempering water	23.97%
Oxidation	Complete in 1 hour.
Maximum safe burning temperature	Above cone 3.
Heat range	Cone 3 to possibly cone 6.
When burned at cone 3—	
Burning shrinkage	8.77%
Total shrinkage	14.31%
Porosity	7.99%
Fracture	Dull, smooth, stony.
Color	Dark red, scums.
Possiblities	Common, front, and paving brick, hollow ware.

ILLINOIS CLAY COMPANY, OGLESBY

(See figure 10)

Coal bed—No. 2.

Sample 26.—Represents roof material up to 10 feet above coal at the outcrop along Vermilion River; medium hard, light-gray shale containing brown iron streaks, hard clay concretions stained with iron oxide and a small amount of carbonaceous matter.

Slaking test ..... Slakes imperfectly.
No screening tests made.
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 7.33%
Volume drying shrinkage 25.40%
Tempering water 33.40%
Oxidation ..... Complete in 5 hours.
Maximum safe burning temperature ..... Cone 04
Heat range ..... Cone 05 to cone 04; bloats above cone 04.
When burned at cone 04—
Burning shrinkage 9.80%
Total shrinkage 7.13%
Porosity 0.38%
Fracture ..... Vitreous
Color ..... Dark cherry red; free from scum.
Possibilities ..... Common and building brick, hollow ware.
Precautions ..... Shale has comparatively short heat range and is sensitive to bloating when overfired, hence should be burned at a safe limit below cone 03.

Sample 53.—Represents roof material from 6 to 16 feet above outcrop of coal along Vermilion River; impurities, sand and sulphur balls; shale somewhat weathered in appearance; contains brown ironstones and iron oxide apparently from decomposed pyrite.

Slaking test ..... Slakes very little.
Residues left on screens—
10 mesh 92.50%
20 mesh 1.24%
35 mesh 1.40%
65 mesh 1.74%
100 mesh 0.73%
150 mesh 0.31%
Passed 150 mesh 2.08%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 5.75%
Volume drying shrinkage 16.56%
Tempering water 28.20%
Oxidation ..... Complete when first trial was drawn.
Maximum safe burning temperature ..... Cone 04
Heat range ..... Short; bloating begins above cone 04.

When burned at cone 04—

Burning shrinkage	8.47%
Total shrinkage	14.22%
Porosity	0.42%
Fracture	Vitreous
Color	Cherry red; scums.
Possibilities	Common brick and hollow ware.
Precautions	Burning should be done at a safe temperature below that at which bloating begins.

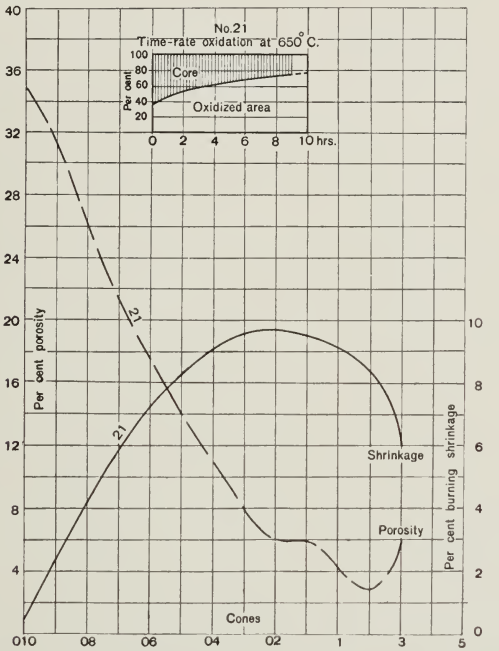


FIG. 11.—Graphic illustration of the laboratory tests of Sample 21, roof material in mine No. 2, St. Paul Coal Company, Cherry.

ST. PAUL COAL COMPANY, MINE NO. 2, CHERRY

(See figure 11)

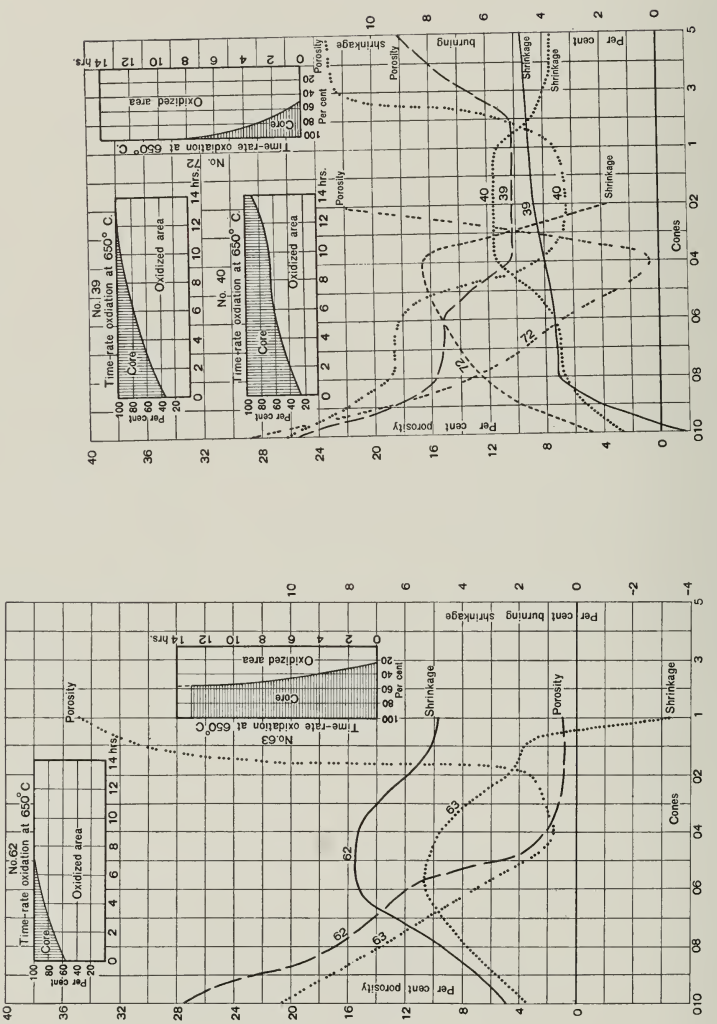
Coal bed—No. 2.

Sample 21.—Represents roof material above coal; sample consists of a mixture of fragments of medium hard, light-gray shale and hard, dark (nearly black) shale; the light-gray shale contains pyrite grains of approximately pinhead size; the dark-colored portion contains hard concretions of clayey matter, pyrite, and numerous shell forms; the dark color is due to carbonaceous matter.

Slaking test ..... Slakes slowly and incompletely.

Residues left on screens—

10 mesh	29.50%
20 mesh	12.30%
60 mesh	7.20%
100 mesh	4.50%
120 mesh	0.48%
Passed 120 mesh	46.02%



FIGS. 12 and 13.—Graphic illustrations of the laboratory tests of Samples 62 and 72, roof material, and of Samples 39, 40, and 63, floor materials, in mine No. 5, Spring Valley Coal Company, Dalzell.

Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 5.58%
Tempering water 25.78%
Oxidation ..... Difficult, 73% oxidized in 9 hours.
Maximum safe burning temperature ..... Cone 2
Heat range ..... Short; bloats at cone 3; cracks in burning.
When burned at cone 2—
Burning shrinkage 8.37%
Total shrinkage 13.95%
Porosity 3.07%
Fracture ..... Vitreous
Color ..... Dark red; scums.
Possibilities ..... An impracticable material, as it is difficult to oxidize, has short heat range, and cracks in burning.

SPRING VALLEY COAL COMPANY, MINE NO. 5, DALZELL

(See figures 12 and 13)

Depth of shaft—413 feet.

Area mined—54 acres; less than 50 per cent is underlain by clay, in east part of mine sandstone lies below the coal.

Coal bed—No. 2.

Thickness of roof—Reported 20 feet at shaft.

Sample 62.—Location in mine, straight W. 2d R. 1st L.; sample represents roof material from 0 to 42 inches above coal; slate-gray shale containing brown spots that show a weak effervescence with hydrochloric acid and a reaction for iron; contains small amount of calcium sulphate; shows occasional slickensides.

Slaking test ..... Incomplete at end of test.
Residues left on screens—
10 mesh 78.40%
20 mesh 6.98%
35 mesh 5.12%
65 mesh 3.80%
100 mesh 1.28%
150 mesh 0.63%
Passed 150 mesh 2.79%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Tendency to warp.
Linear drying shrinkage 4.20%
Volume drying shrinkage 13.80%
Tempering water 22.20%
Oxidation ..... Complete in 7 hours.
Maximum safe burning temperature ..... Cone 04
Heat range ..... Short; occasional surface pitting occurs.
When burned at cone 04—
Burning shrinkage 7.61%
Total shrinkage 11.81%
Porosity 2.04%
Fracture ..... Vitreous
Color ..... Medium dark red; scums excessively.
Possibilities ..... Common brick.

Sample 72.—Location in mine, N. 6th R., one-half mile from shaft; sample represents roof material up to 5 feet above coal; medium hard, gray shale, with hard brown patches; contains numerous pyrite granules, calcium sulphate, and iron carbonate.

Residues left on screens—	
10 mesh	70.95%
20 mesh	70.41%
35 mesh	8.21%
65 mesh	6.16%
100 mesh	2.58%
150 mesh	1.02%
Passed 150 mesh	0.69%
Plasticity	Fair
Molding qualities	Good
Drying properties	Good
Linear drying shrinkage	4.23%
Volume drying shrinkage	13.40%
Tempering water	23.04%
Oxidation	Complete in 8 hours.
Maximum safe burning temperature	Cone 04
Heat range	Cone 06 to cone 04; bloats above cone 04; surface pits a little.
When burned at cone 04—	
Burning shrinkage	8.26%
Total shrinkage	12.49%
Porosity	0.70%
Fracture	Vitreous
Color	Light cherry red; scums.
Possibilities	Common and front brick, hollow ware.

Sample 39.—Location in mine, straight W. 2d S., 1st left; sample represents floor material from 0 to 14 inches below coal; structure resembles that of fire clay; medium hard, light-gray clay, stained brown in spots; contains carbonaceous matter as plant fossils, granules of iron carbonate, and small calcium carbonate concretions.

Slaking test	Slakes in 39 hours.
Residues left on screens—	
10 mesh	4.07%
20 mesh	1.95%
35 mesh	5.21%
65 mesh	7.22%
100 mesh	6.42%
150 mesh	2.52%
Passed 150 mesh	72.61%
Plasticity	Good
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	5.81%
Tempering water	19.60%
Oxidation	Complete in 13 hours.
Maximum safe burning temperature	Cone 2
Heat range	Good, cone 04 to cone 2. Occasional surface pits occur. Bloats above cone 2.

When burned at cone 2—
- Burning shrinkage 4.57%
- Total shrinkage 10.38%
- Porosity 9.47%
- Fracture ..... Stony
- Color ..... Light salmon at cone 010, changes to light brown at cone 04; color does not change above this temperature.

Possibilities ..... Common and face brick, hollow ware.

Precautions ..... Would require considerable care during oxidation.

Sample 40.—Same location as Sample 39; sample represents floor material from 14 to 24 inches below coal; similar in appearance to Sample 39.

Slaking test ..... Slakes slowly and imperfectly.

Residues left on screen—
- 10 mesh 7.60%
- 20 mesh 6.54%
- 35 mesh 13.70%
- 65 mesh 11.05%
- 100 mesh 8.45%
- 150 mesh 3.75%
- Passed 150 mesh 48.97%

Plasticity ..... Fair

Molding properties ..... Good

Drying properties ..... Good
- Linear drying shrinkage 5.82%
- Tempering water 19.60%

Oxidation ..... Difficult, 93% oxidized in 14 hours.

Maximum safe burning temperature ..... Cone 1

Heat range ..... Cone 04 to cone 1. Occasional surface pits occur. Bloating occurs above cone 1.

When burned at cone 1—
- Burning shrinkage 5.60%
- Total shrinkage 11.42%
- Porosity 7.33%
- Fracture ..... Stony
- Color ..... Salmon at cone 010, changes to brown at cone 04. Color does not change above this temperature.

Possibilities ..... Common and front brick, hollow ware.

Precautions ..... Would require careful oxidizing.

Sample 63.—Location in mine, straight W. 2d R. 1st L.; sample represents floor material below coal; a mixture of light-gray with dark, almost black, clay stained brown in spots; shows occasional sickensides; contains considerable carbon as plant fossils.

Slaking test ..... Slaked in 11 hours to a plastic mass.

Residues left on screens—
- 10 mesh 0.07%
- 20 mesh 0.04%
- 35 mesh 0.11%
- 65 mesh 0.26%
- 100 mesh 0.23%
- 150 mesh 0.35%
- Passed 150 mesh 98.94%

Plasticity ..... Good

Molding properties ..... Good

Drying properties ..... Warps in drying
Linear drying shrinkage 10.28%
Tempering water 31.00%
Oxidation ..... Difficult, 56% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 06
Heat range ..... Very short; bloats above cone 06; cracks in burning.
When burned at cone 06—
Burning shrinkage 5.34%
Total shrinkage 15.62%
Porosity 7.08%
Fracture ..... Dense, stony.
Color ..... Light salmon at cone 010, changes to light brown at cone 08.
Possibilities ..... Very unsuitable material, as it has high-drying shrinkage and warps, is difficult to oxidize, has short heat range, cracks in burning, and is sensitive to overfiring as indicated by bloating.

MARQUETTE THIRD VEIN COAL COMPANY, MARQUETTE MINE, MARQUETTE

(See figure 14)

Depth of shaft—282 feet.

Coal bed—No. 2.

Sample 11.—Sent by company; represents roof of coal; medium hard, gray shale; contains carbonaceous material, granular concretions of partly decomposed pyrite, and calcium sulphate.

Slaking test ..... Slakes slowly and incompletely.
Residues left on screens—
10 mesh 48.50%
20 mesh 6.70%
60 mesh 8.00%
100 mesh 0.65%
120 mesh 0.93%
Passed 120 mesh 35.22%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 6.44%
Volume drying shrinkage 20.30%
Tempering water 26 80%
Oxidation ..... Difficult, 92% oxidized in 8 hours.
Maximum safe burning temperature ..... Cone 02
Heat range ..... Short; cracks in burning; bloats above cone 02.
When burned at cone 02—
Burning shrinkage 9.25%
Total shrinkage 15.69%
Porosity 8.29%
Fracture ..... Vitreous
Color ..... Red, scums considerably.
Possibilities ..... A troublesome material, as it is difficult to oxidize, cracks in burning, has short heat range, is sensitive to overburning, and scums excessively.

Sample 14.—Sent by company; represents floor of coal; medium hard, light-gray shale; contains calcium sulphate and carbonaceous matter as plant fossils.

Slaking test ..... Slakes slowly.

Residues left on screens—	
10 mesh	0.00%
20 mesh	0.10%
60 mesh	0.10%
100 mesh	0.10%
120 mesh	0.00%
Passed 120 mesh	99.70%
Plasticity	High
Molding properties	Good

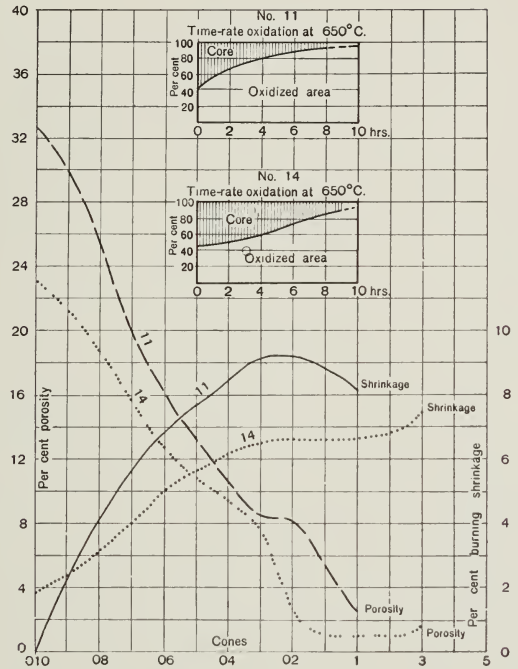


FIG. 14.—Graphic illustration of the laboratory tests of Sample 11, roof material, and Sample 14, floor material, in Marquette mine, Marquette Third Vein Coal Company, Marquette.

Drying properties	Good
Linear drying shrinkage	6.66%
Volume drying shrinkage	22.59%
Tempering water	23.58%
Oxidation	Difficult, 89% oxidized in 9 hours.
Maximum safe burning temperature	Cone 3
Heat range	Cone 02 to cone 3, cracks in burning.
When burned at cone 3—	
Burning shrinkage	7.48%
Total shrinkage	14.14%
Porosity	1.74%
Fracture	Stony
Color	Dark, dull red; scums.
Possibilities	A very unsuitable material, as it is difficult to oxidize and cracks in burning.

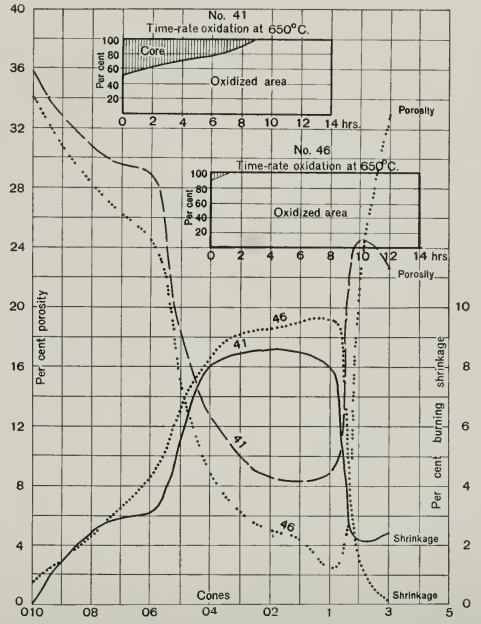


FIG. 15—Graphic illustration of the laboratory tests of Samples 41 and 46, roof materials in mine No. 6, Big Four Wilmington Coal Company, Coal City.

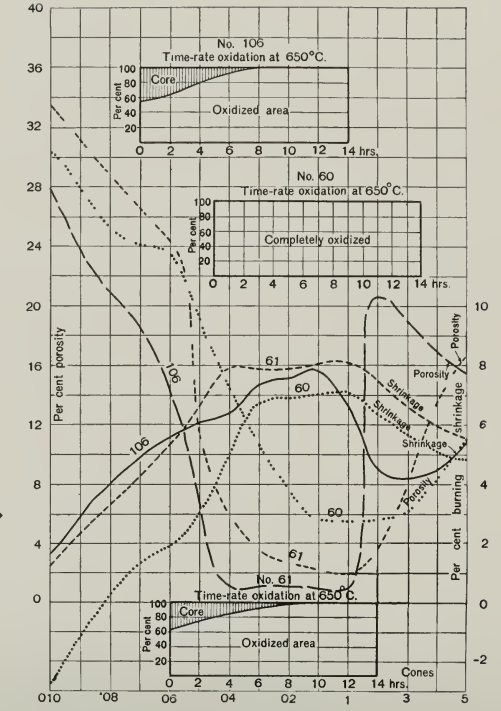


FIG. 16.—Graphic illustration of the laboratory tests of Samples 60, 61, and 106, floor materials in mine No. 6, Big Four Wilmington Coal Company, Coal City.

BIG FOUR WILMINGTON COAL CO., MINE NO. 6, COAL CITY

(See figures 15 and 16)

Depth of shaft—95 feet.

Area mined—200 acres.

Coal bed—No. 2.

Thickness of roof—Reported to be 35 feet like samples.

Sample 41.—Location in mine, S. entry, 2,700 feet from shaft; sample represents roof material above coal; medium soft gray roof shale, somewhat sandy; contains numerous well-defined plant fossils and occasional granules of lime-iron carbonate.

Slaking test..Very little affected, broke up into a few large fragments.
Residues left on screens..Practically all remained on 10-mesh screen.
Plasticity ..... Low
Molding properties.....Tears at the corners of the die.
Drying properties ..... Good
Linear drying shrinkage 3.43%
Tempering water 20.70%
Oxidation .....Complete in 9 hours.
Maximum safe burning temperature..... Cone 1
Heat range .....Cone 04 to cone 1; occasional surface pits occur; bloats above cone 1.
When burned at cone 1—
Burning shrinkage 7.98%
Total shrinkage 11.41%
Porosity 8.79%
Fracture .....Dense, stony.
Color .....Cherry red; free from scum.
Possibilities .....Common and front brick.
Precautions .....Clay is somewhat short and would require fine grinding and thorough tempering to work without trouble in the die.

Sample 46.—Location in mine, NE. entry 1,500 feet from shaft; sample represents roof material above coal; medium soft, gray, somewhat sandy, micaceous shale; otherwise very uniform in appearance.

Slaking test .....No effect noticeable.
Residues left on screens—Practically all residue remains on 10-mesh screen.
Plasticity ..... Fair
Molding properties ..... Fair
Drying properties ..... Good
Linear drying shrinkage 2.84%
Tempering water 19.65%
Oxidation .....Complete in 1 hour.
Maximum safe burning temperature ..... Cone 1
Heat range .....Good, cone 04 to cone 1
When burned at cone 1—
Burning shrinkage 9.62%
Total shrinkage 12.46%
Porosity 2.83%
Fracture .....Dull, dense, uniform.
Color .....Dark red; comparatively free from scum.
Possibilities .....Common and front brick.

Sample 60.—Location in mine, in entry 200 feet east of shaft; sample represents 7 feet of floor material; medium hard, light-gray clay of fine sandy character; apparently free from carbonaceous matter, pyrite, carbonates, and sulphates.

Slaking test ..... Partially slaked at end of test.
Residues left on screens—
10 mesh 54.00%
20 mesh 0.54%
35 mesh 0.54%
65 mesh 2.41%
100 mesh 0.39%
150 mesh 0.23%
Passed 150 mesh 41.89%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 4.28%
Tempering water 20.00%
Oxidation ..... Complete when first trial was drawn.
Maximum safe burning temperature ..... Cone 1
Heat range ..... Cone 03 to cone 1; bloats above cone 1.
When burned at cone 1—
Burning shrinkage 7.21%
Total shrinkage 11.49%
Porosity 5.77%
Fracture ..... Fine grained, stony.
Color ..... Dark dull red.
Possibilities ..... Common and front brick, hollow ware.

Sample 61.—Location in mine, in pump room; sample represents 2 feet of floor material; soft, weathered, light-gray shale stained yellow to brown in spots; contains some carbonaceous matter and occasional pyrite concretions.

Slaking test ..... Slakes in 13 hours.
Residues left on screens—
10 mesh 9.82%
20 mesh 0.25%
35 mesh 1.15%
65 mesh 2.05%
100 mesh 1.75%
150 mesh 0.84%
Passed 150 mesh 93.14%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 5.71%
Tempering water 24.30%
Oxidation ..... Complete in 9 hours.
Maximum safe burning temperature ..... Cone 1
Heat range ..... Cone 04 to cone 1.
When burned at cone 1—
Burning shrinkage 8.03%
Total shrinkage 13.74%
Porosity 2.00%
Fracture ..... Vitreous
Color ..... Medium dull red; scums a little.
Possibilities ..... Common and front brick, hollow ware.

Sample 106.—Location in mine, face 2,700 feet south of shaft; sample represents floor material immediately below coal; medium hard, light to dark-gray clay; structure resembles that of fire clay; shows slickensides; contains carbonaceous matter as plant fossils and calcium sulphate.

Slaking test ..... Slakes in 11 hours.
Residues left on screens—
10 mesh 0.10%
20 mesh 0.70%
35 mesh 3.65%
65 mesh 4.74%
100 mesh 2.99%
150 mesh 1.39%
Passed 150 mesh 86.43%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Slight tendency to warp; scums.
Linear drying shrinkage 5.95%
Tempering water 23.40%
Oxidation ..... Complete in 8 hours.
Maximum safe burning temperature ..... Cone 01
Heat range ..... Cone 04 to cone 01; bloats above cone 01.
When burned at cone 01—
Burning shrinkage 7.79%
Total shrinkage 13.74%
Porosity 1.07%
Fracture ..... Vitreous
Color ..... Very light red; scums badly.
Possiblities ..... Common brick, hollow ware.
Precautions ..... To reduce shrinkage and to overcome warping, sand or grog should be added to the clay.

CHICAGO, WILMINGTON & VERMILION COAL CO., MINE NO. 1, SOUTH WILMINGTON

(See figures 17 and 18)

Depth of shaft—190 feet.
Area mined—640 acres.
Coal bed—No. 2.
Thickness of roof—Reported 35 feet of material at shaft like samples.
Thickness of floor—30 inches at pump room.
Impurities in roof—Few sulphur balls, some sand.

Sample 55.—Represents roof material up to 3 feet above coal; medium hard, dark-gray shale, apparently free from carbon, pyrite, and carbonates; contains occasional hard clay concretions streaked with brown.

Slaking test ..... Slakes imperfectly.
Residues left on screens—
10 mesh 84.50%
20 mesh 4.55%
35 mesh 3.45%
65 mesh 1.71%
100 mesh 0.66%
150 mesh 0.29%
Passed 150 mesh 4.84%
Plasticity ..... Fair
Molding properties ..... Fair

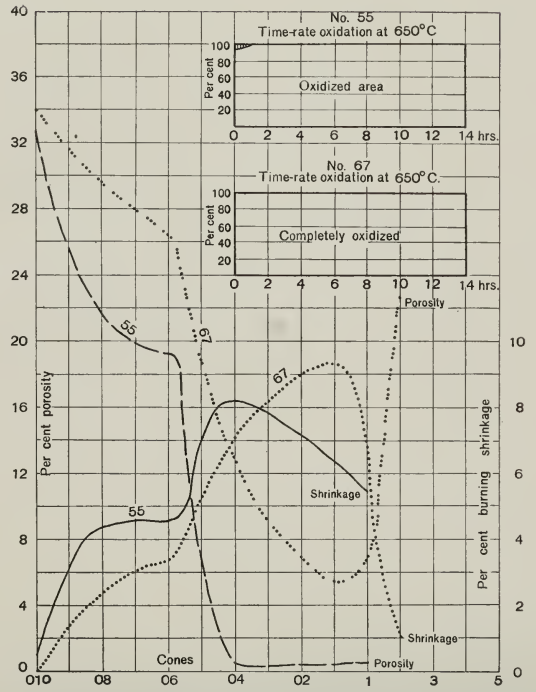


Fig. 17.—Graphic illustration of laboratory tests of Samples 55 and 67, roof materials in mine No. 1, Chicago, Wilmington & Vermilion Coal Company, South Wilmington.

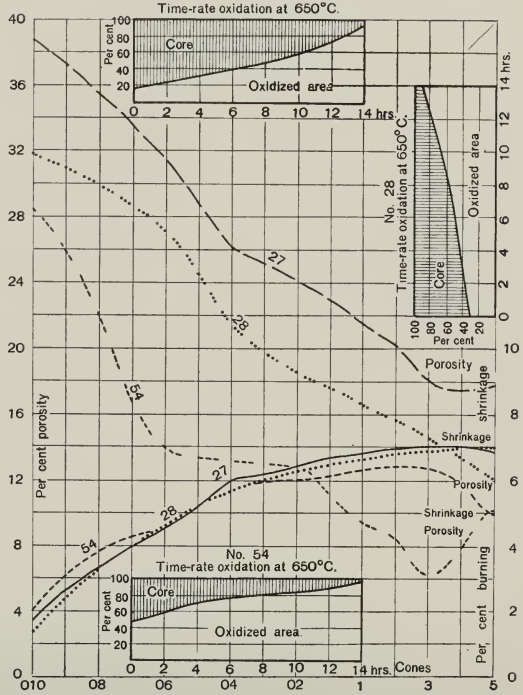


Fig. 18.—Graphic illustration of laboratory tests of Samples 27, 28, and 54, floor materials in mine No. 1, Chicago, Wilmington & Vermilion Coal Company, South Wilmington.

Drying properties ..... Good
Linear drying shrinkage 4.05%
Volume drying shrinkage 11.14%
Tempering water 20.30%
Oxidation ..... Complete in 1 hour.
Maximum safe burning temperature ..... Cone 04
Heat range ..... Very short; begins to bloat above cone 04.
When burned at cone 04—
Burning shrinkage 8.18%
Total shrinkage 12.23%
Porosity 0.41%
Fracture ..... Vitreous
Color ..... Dark cherry red; comparatively free from scum.
Possibilities ..... Common and front brick, hollow ware.
Precautions ..... Because of short heat range the products out of kiln would vary considerably in color, size, and porosity.

Sample 67.—Location in mine, on SE. entry; sample represents roof material up to 6 feet above coal; hard, light-gray roof shale of fine sandy structure, comparatively uniform and free from deleterious matter.

Slaking test ..... Very little slaked at end of test.
Residues left on screens—
10 mesh 93.29%
20 mesh 1.26%
35 mesh 0.87%
65 mesh 0.72%
100 mesh 0.42%
150 mesh 0.26%
Passed 150 mesh 3.18%
Plasticity ..... Fair
Molding properties ..... Fair
Drying properties ..... Good
Linear drying shrinkage 2.76%
Volume drying shrinkage 8.78%
Tempering water 19.80%
Oxidation ..... Completely oxidized when first trial was drawn.
Maximum safe burning temperature ..... Cone 01
Heat range ..... Cone 04 to cone 01; bloats above cone 01.
When burned at cone 01—
Burning shrinkage 9.35%
Total shrinkage 12.11%
Porosity 5.50%
Fracture ..... Dense, stony.
Color ..... Dark, cherry red; very slightly scummed.
Possibilities ..... Common and front brick.

Sample 27.—Location in mine, face SE. entry; sample represents floor clay 4 to 13 inches below coal, the first 4 inches immediately below coal was a carbonaceous clay; hard, blue-gray clay with structure resembling that of fire clay; contains considerable bituminous matter in thin seams and streaks and nodules of pyrite.

Slaking test ..... Slakes slowly and imperfectly.
Residues left on screens—
10 mesh 45.38%
20 mesh 11.92%
35 mesh 12.84%
65 mesh 12.31%
100 mesh 4.47%
150 mesh 1.91%
Passed 150 mesh 11.17%

Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 5.86%
Volume drying shrinkage 18.40%
Tempering water 22.50%
Oxidation ..... Difficult, 92% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 5
Heat range ..... Cone 1 to cone 5, very sensitive to flashing; high porosity of trials due to burning out of carbon. Tends to bloat above cone 5.
When burned at cone 5—
Burning shrinkage 6.91%
Total shrinkage 12.77%
Porosity 17.86%
Fracture ..... Stony
Color ..... Dark buff at cone 010, grayish buff at cone 5.
Possibilities ..... Common and front brick; fireproofing.
Precautions ..... Clay would require careful burning during oxidation period.

Sample 28.—Same location in mine as Sample 27; sample represents floor clay from 13 to 27 inches below coal; structure characteristically that of a fire clay; shows well-developed slickensides; contains gypsum, carbonaceous matter, as plant fossils, and nodules of partly decomposed pyrite.

Slaking test ..... Slakes in 15 hours.
Residues left on screens—
10 mesh 14.90%
20 mesh 10.27%
35 mesh 22.42%
65 mesh 6.98%
100 mesh 0.96%
150 mesh 1.32%
Passed 150 mesh 43.15%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 6.92%
Tempering water 23.40%
Oxidation ..... Difficult, 90% oxidized in 14 hours.
Maximum safe burning temperature ..... Above cone 5
Heat range ... Temperature not carried high enough to determine this.
When burned at cone 5—
Burning shrinkage 6.97%
Total shrinkage 13.89%
Porosity 12.24%
Fracture ..... Stony, shows numerous black specks.
Color ..... Buff at cone 010, gray buff at cone 04, gray at cone 5.
Possibilities ..... Common and front brick, hollow blocks, fireproofing. Though difficult to oxidize at 650°C, the clay remains sufficiently porous above 900°C so that oxidation progresses without danger.

Sample 54.—Location in mine, two-thirds mile out on SE. entry; sample represents floor material from 20 to 36 inches below coal, the material from 0 to 11 inches below coal was a black clay, the clay from 11 to 20 inches was not tested; structure of sample characteristically that of fire clay; dark-blue gray;

numerous well-developed slickensides; contains carbon as plant fossils and nodules of altered pyrite.

Slaking test ..... Slakes in 147 hours.
Residues left on screens—
10 mesh 17.35%
20 mesh 14.60%
35 mesh 21.40%
65 mesh 18.70%
100 mesh 7.78%
150 mesh 3.38%
Passed 150 mesh 16.79%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 6.01%
Tempering water 24.06%
Oxidation ..... Complete in 14 hours.
Maximum safe burning temperature ..... Cone 3
Heat range ..... Cone 04 to cone 3; bloating begins above cone 3; clay is sensitve to flashing.
When burned at cone 3—
Burning shrinkage 6.43%
Total shrinkage 12.44%
Porosity 6.18%
Fracture ..... Stony
Color ..... Dark buff at cone 010, changes to brownish gray at cone 04; no color change from cone 04 to cone 3.
Possibilities ..... Common and front brick, hollow ware.

LA SALLE COUNTY CARBON COAL COMPANY, LA SALLE SHAFT, LA SALLE

(See figure 19)

Depth of shaft—395 feet.
Coal bed—No. 2.

Sample 8.—Represents roof material above coal; hard gray shale; contains numerous concretions of pyrite and iron carbonate, and shows traces of calcium sulphate.

Slaking test ..... Gradually slakes to a plastic mass.
Residues left on screens—
10 mesh 10.80%
20 mesh 1.55%
60 mesh 0.69%
100 mesh 0.98%
120 mesh 0.00%
Passed 120 mesh 85.98%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 5.26%
Tempering water 24.86%
Oxidation ..... Complete in 8 hours.
Maximum safe burning temperature ..... Cone 01
Heat range ..... Cone 02 to cone 01; bloats above cone 01.

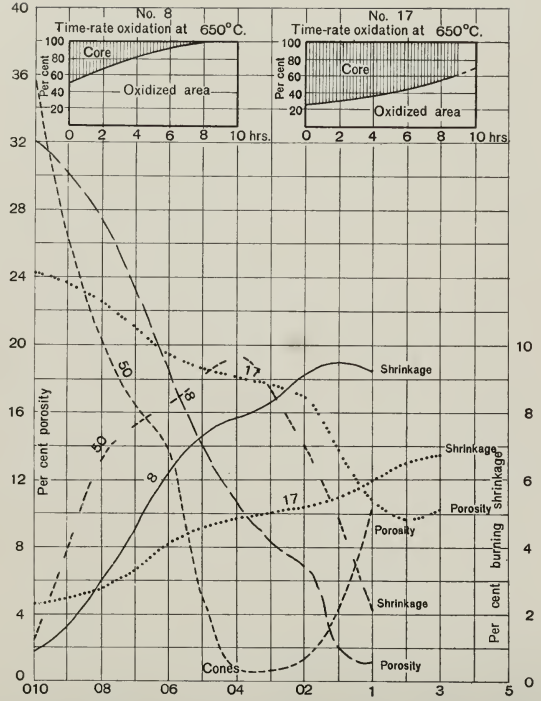


Fig. 19.—Graphic illustration of laboratory tests of Samples 8 and 50, roof materials, and Sample 17, floor material, in La Salle mine, La Salle County Carbon Coal Company, La Salle.

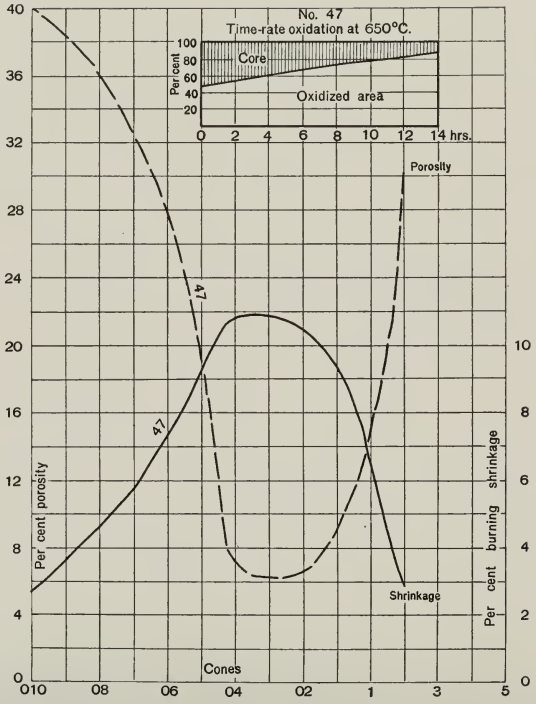


Fig. 20.—Graphic illustration of the laboratory tests of Samples 47 and 80, roof material in M. & H. mine, Matthiessen & Hegeler Zinc Company, La Salle.

When burned at cone 01—
- Burning shrinkage 9.48%
- Total shrinkage 14.74%
- Porosity 1.69%
- Fracture ..... Vitreous, brittle.
- Color ..... Dark red; scums excessively.

Possibilities ..... Common brick, hollow ware.

Sample 50.—Represents roof material above coal; light-gray shale; contains a little carbonaceous matter and numerous granules of lime-iron carbonate.

Slaking test ..... Sample as received had been wet and slaked.

Residues left on screens—
- 10 mesh 1.12%
- 20 mesh 5.20%
- 35 mesh 7.06%
- 65 mesh 5.56%
- 100 mesh 2.30%
- 150 mesh 1.03%
- Passed 150 mesh 77.64%

Plasticity ..... Good

Molding properties ..... Good

Drying properties ..... Good
- Linear drying shrinkage 5.15%
- Volume drying shrinkage 13.36%
- Tempering water 26.50%

Oxidation ..... No trials made.

Maximum safe burning temperature ..... Cone 04

Heat range ..... Short; serious surface pitting occurs due to lime-iron granules; bloats above cone 04.

When burned at cone 04—
- Burning shrinkage 9.66%
- Total shrinkage 14.81%
- Porosity 0.73%
- Fracture ..... Vitreous
- Color ..... Light red at cone 06 to medium red at cone 04; scums a little.

Possibilities ..... An unsafe material because it has short heat range and pits excessively at the surface.

Sample 17.—Represents floor material below coal; medium hard, dark slate-gray fire clay; shows well-developed slickensides; contains pyrite, carbonaceous matter as plant fossils, and traces of gypsum.

Slaking test ..... Slakes rapidly to a plastic mass.

Residues left on screens—
- 10 mesh 24 50%
- 20 mesh 6.70%
- 60 mesh 6.40%
- 100 mesh 0.84%
- 120 mesh 0.93%
- Passed 120 mesh 61.56%

Plasticity ..... Good

Molding properties ..... Good

Drying properties ..... Good
- Linear drying shrinkage 11.46%
- Volume drying shrinkage 37.82%
- Tempering water 28.42%

Oxidation ..... Difficult, 62% oxidized in 9 hours.

Maximum safe burning temperature ..... Above cone 3.

Heat range ..... Temperature not carried high enough to determine this; fusion temperature, cone 29½ (1720°C).

When burned at cone 3—
- Burning shrinkage 6.75%
- Total shrinkage 18.21%
- Porosity 10.40%
- Fracture ..... Stony
- Color ..... Light buff; scums slightly.

Possibilities ..... Common and building brick, fireproofing, and as a bond clay for No. 2 fire brick; when washed and screened it may be used for stoneware. The clay remains porous up to a comparatively high temperature, hence can be oxidized easily.

MATTHIESSEN & HEGELER ZINC COMPANY, M. & H. MINE, LA SALLE

(See figure 20)

Depth of shaft—310 feet.

Coal bed—No. 2.

Sample 47.—Location in mine, 300 yards from shaft beyond stable; sample represents roof material up to 24 inches above coal; mixture of hard, dark-gray and dull-black shale with occasional conchoidal lumps of very light-weight black material resembling cannel coal and burning readily in a gas flame; the gray shale contains occasional streaks of carbonaceous matter and the black shale contains a high percentage of finely distributed carbon.

Slaking test ..... Very little affected.

Residues left on screens... Practically all remained on 10-mesh screen.

Plasticity ..... Fair

Molding properties ..... Slightly difficult to work in the die, tears a little at the corners.

Drying properties ..... Good
- Linear drying shrinkage 2.83%
- Tempering water 18.80%

Oxidation ..... Difficult, 91% oxidized in 14 hours.

Maximum safe burning temperature ..... Cone 02

Heat range ..... Cone 04 to cone 02; bloats above cone 02.

When burned at cone 02—
- Burning shrinkage 10.48%
- Total shrinkage 13.31%
- Porosity 6.50%
- Fracture ..... Dull, dense.
- Color ..... Dark red.

Possibilities ..... A dangerous material as it is difficult to mold, difficult to oxidize, high in carbon, sensitive to bloating.

Sample 80.—Location in mine, 200 yards from shaft on SW. entry; sample represents roof shale up to 5 feet above coal; dull black; medium soft; principally carbonaceous matter containing a noticeable amount of pyrite.

Slaking test ..... Does not slake.

Residues left on screens ..... All on 10-mesh screen.

Plasticity ..... Lacking

Molding properties.. Impossible to mold, hence no briquets were made.

Possibilities ..... Impossible material for clay products, as it is excessively high in carbonaceous matter, devoid of plasticity, and impossible to mold in die.

ILLINOIS ZINC COMPANY, BLACK HOLLOW MINE, OGLESBY

(See figure 21)

Kind of mine—Slope.

Area mined—85 to 100 acres.

Coal bed—No. 2.

Sample 12.—Sent by company; sample represents roof material above coal; hard, calcareous, light-gray shale streaked with brown; contains partly decomposed pyrite, nodules of calcium-iron carbonate, carbonaceous matter, and calcium sulphate.

Slaking test	Slakes in 4 hours.
Residues left on screens—	
10 mesh	1.00%
20 mesh	0.50%
60 mesh	2.50%
100 mesh	0.20%
120 mesh	0.10%
Passed 120 mesh	95.70%
Plasticity	Good
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	6.24%
Volume drying shrinkage	18.96%
Tempering water	25.39%
Oxidation	Difficult, 72% oxidized in 9 hours.
Maximum safe burning temperature	Cone 01
Heat range	Very short; bloats above cone 01; cracks in burning; surface pits due to calcium-iron granules.
When burned at cone 01—	
Burning shrinkage	10.65%
Total shrinkage	16.89%
Porosity	3.25%
Fracture	Vitreous
Color	Dark red; scums.
Possibilities	Very unsuitable material, as it is difficult to oxidize, has short heat range, cracks in burning, pits, and is sensitive to overfiring.

Sample 76.—Location of sample, 1st S. 160 feet in at a depth of 109 feet; sample represents roof material from 0 to 24 inches above coal; impurities, some sulphur balls; light-gray and dark-gray fragments of shale; contains gypsum, iron carbonate granules, and decomposed pyrite.

Slaking test	Imperfectly slaked at end of test
Residues left on screens—	
10 mesh	34.77%
20 mesh	24.78%
35 mesh	18.64%
65 mesh	9.38%
100 mesh	2.64%
150 mesh	1.27%
Passed 150 mesh	8.52%
Plasticity	Fair
Molding properties	Good

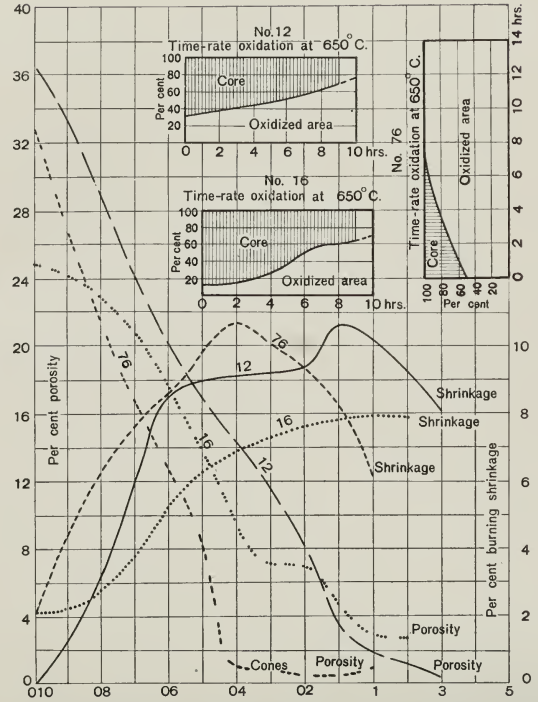


FIG. 21.—Graphic illustration of the laboratory tests of Samples 12 and 76, roof materials, and Sample 16, floor material, in Black Hollow mine, Illinois Zinc Company, Oglesby.

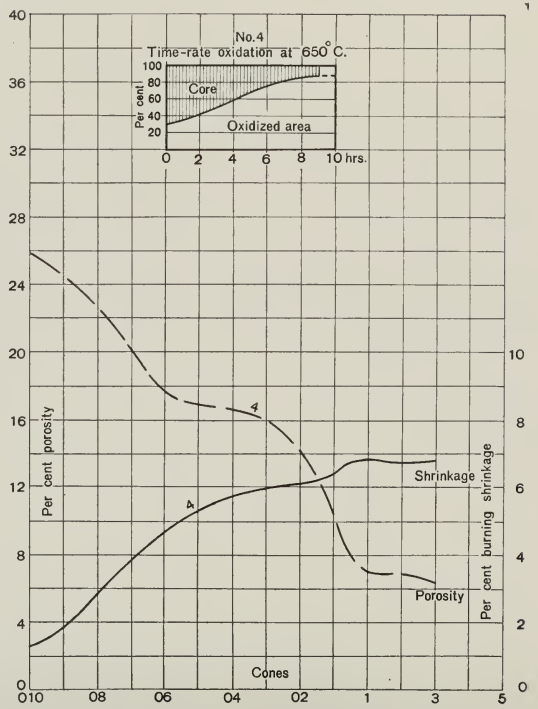


FIG. 22.—Graphic illustration of the laboratory tests of Sample 4, floor material in Oglesby mine. Oglesby Coal Company, Oglesby.

Drying properties ..... Good
Linear drying shrinkage 6.84%
Volume drying shrinkage 20.90%
Tempering water 28.30%
Oxidation .....Complete in 7 hours
Maximum safe burning temperature .....Cone 04
Heat range .....Very short; bloats above cone 04; surface pits.
When burned at cone 04—
Burning shrinkage 10.69%
Total shrinkage 17.53%
Porosity 1.04%
Fracture .....Vitreous
Color .....Red brown; scums.
Possibilities .....Common brick; hollow ware.

Sample 16.—Sent by company; sample represents floor material below coal; medium soft, gray clay with the structure characteristic of fire clay; slickensides prominent; contains pyrite, lime-iron granules, carbonaceous matter as plant fossils, and a trace of calcium sulphate.

Slaking test .....Slakes in one hour.
Residues left on screens—
10 mesh 0.00%
20 mesh 1.10%
60 mesh 0.80%
100 mesh 0.50%
120 mesh 0.10%
Passed 120 mesh 98.50%
Plasticity ..... High
Molding properties ..... Good
Drying properties .....High shrinkage
Linear drying shrinkage..... 11.42%
Volume drying shrinkage 39.04%
Tempering water 28.43%
Oxidation .....Difficult; 64% oxidized in 9 hours.
Maximum safe burning temperature.....Above cone 2.
Heat range .....Cone 1 to approximately cone 5.
When burned at cone 2—
Burning shrinkage 7.90%
Total shrinkage 19.32%
Porosity 2.83%
Fracture ..... Stony
Color .....Buff at cone 010, brownish-gray at cone 03 to cone 1; scums.
Possibilities .....Common and front brick, hollow ware.
Precautions .....Burning should be done under strong oxidizing conditions. Though difficult to oxidize at 650°C, the clay remains sufficiently porous above 900°C so that oxidation continues for some time before the clay becomes sufficiently dense to retard the action. The addition of grog would be beneficial.

OGLESBY COAL COMPANY, OGLESBY MINE, OGLESBY

(See figure 22)

Coal bed—No. 2.

Sample 4.—Sent by company; represents floor clay of coal; medium hard, gray fire clay; shows well-developed slickensides; contains occasional small calcium carbonate concretions, pyrite granules, traces of calcium carbonate, and carbonaceous matter.

Slaking test	Slakes in 2 hours.
Residues left on screens—	
10 mesh	0.65%
20 mesh	0.95%
60 mesh	0.65%
100 mesh	0.93%
120 mesh	0.19%
Passed 120 mesh	96.65%
Plasticity	High
Molding properties	Good
Drying properties	Warps; high-drying shrinkage.
Linear drying shrinkage	10.65%
Volume drying shrinkage	36.91%
Tempering water	29.75%
Oxidation	Difficult, 84% oxidized in 9 hours.
Maximum safe burning temperature	Above cone 3
Heat range	Good, cone 1 to possibly cone 6.
When burned at cone 3—	
Burning shrinkage	6.78%
Total shrinkage	17.43%
Porosity	6.19%
Fracture	Stony
Color	Light buff at cone 010 to gray buff at cone 3.
Possibilities	Common and front brick, hollow ware.
Precautions	Must be oxidized with care; the addition of sand or grog (clay calcined and ground) would reduce shrinkage and warping.

GRAY & JONES COAL COMPANY, SENECA

(See figures 23 and 24)

Depth of shaft—130 feet.

Area mined—Mine has been opened but short distance.

Coal bed—No. 2.

Thickness of roof—Reported 60 feet in some places.

Thickness of floor—Reported to be 12 feet.

Impurities in roof—Small bowlders in layers.

Sample 42.—Location in mine, straight north from shaft; sample represents roof material up to 6 feet above coal; medium hard, light-gray shale stained brown in spots; contains streaks of pyrite and calcium sulphate, apparently free from carbon.

Slaking test ..... Very little affected.
Residues left on screens—
10 mesh 70.12%
20 mesh 8.70%
35 mesh 6.80%
65 mesh 4.48%
100 mesh 1.70%
150 mesh 0.84%
Passed 150 mesh 7.36%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 4.44%
Tempering water 22.20%
Oxidation ..... Complete in 10 hours.
Maximum safe burning temperature ..... Cone 04
Heat range ..... Very short, bloats above cone 04.
When burned at cone 04—
Burning shrinkage 8.22%
Total shrinkage 12.66%
Porosity 0.56%
Fracture ..... Vitreous
Color ..... Medium red, scums very badly.
Possibilities ..... Common brick and hollow ware.
Precautions ..... Should be burned at safe limit below bloating temperature; would require considerable care during oxidation stage of the burn.

Sample 48.—Location in mine, 2d R. entry; sample represents roof material up to 7 feet above coal; medium hard, light-gray shale stained brown in spots; contains some calcium sulphate and numerous hard, clay-like concretions of calcium carbonate streaked with pyrite.

Slaking test ..... Imperfectly slaked at end of test.
Residues left on screens—
10 mesh 90.42%
20 mesh 2.95%
35 mesh 2.00%
65 mesh 1.22%
100 mesh 0.45%
150 mesh 0.25%
Passed 150 mesh 2.71%
Plasticity ..... Fair
Molding properties ..... Fair
Drying properties ..... Good
Linear drying shrinkage 3.63%
Volume drying shrinkage 11.25%
Tempering water 16.30%
Oxidation ..... Complete in 6 hours.
Maximum safe burning temperature ..... Cone 02
Heat range ..... Cone 04 to cone 02; surface pits very numerous.
When burned at cone 02—
Burning shrinkage 8.80%
Total shrinkage 12.43%
Porosity 0.69%
Fracture ..... Vitreous
Color ..... Dark red, scums excessively.
Possibilities ..... Common brick and hollow blocks.

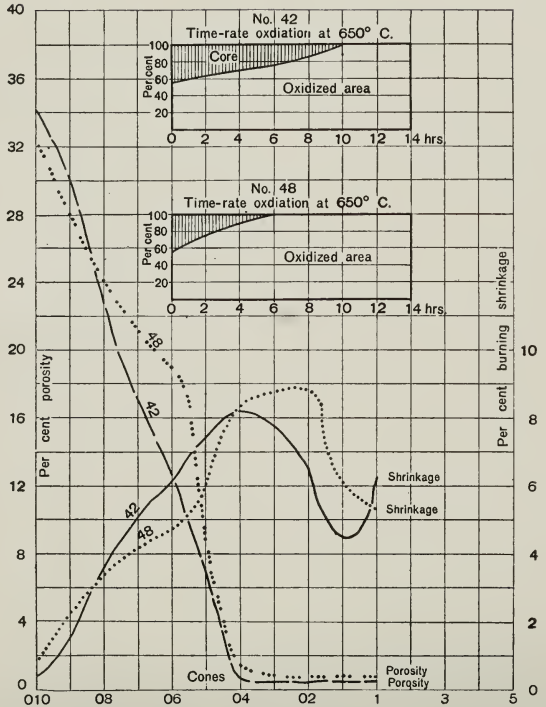


FIG. 23.—Graphic illustration of the laboratory tests of Samples 42 and 48, roof materials, in the mine of Gray & Jones Coal Company, Seneca.

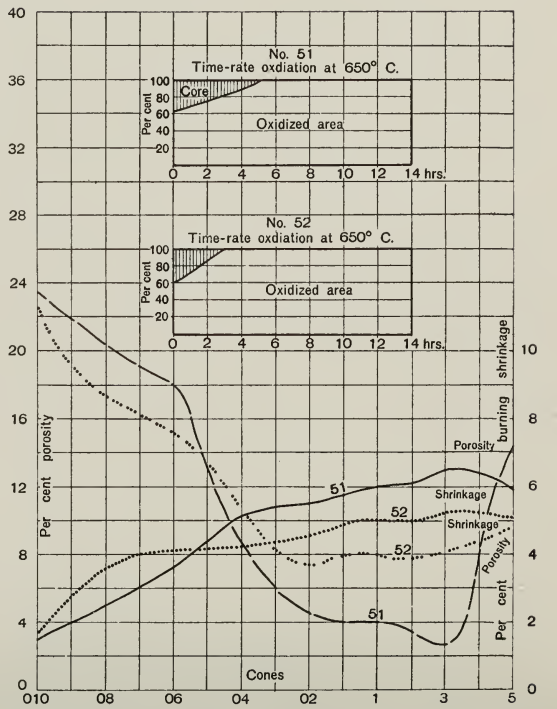


FIG. 24.—Graphic illustration of the laboratory tests of Samples 51 and 52 in the mine of Gray & Jones Coal Company, Seneca.

Sample 51.—Location in mine, NW. room, No. 4 sump; sample tested composed of a mixture of two samples of floor material, one from 0 to 38 inches below coal, the other from 38 to 45 inches below coal at same place; light-gray, partly slaked clay; contains sulphur balls next to coal, pyrite, lime concretions, granules of iron carbonate, finely divided lime, and a small amount of carbonaceous matter as fragments of coal.

Slaking test	Complete in 12 hours.
Residues left on screens —	
10 mesh	1.01%
20 mesh	6.22%
35 mesh	22.95%
65 mesh	13.50%
100 mesh	4.59%
150 mesh	3.13%
Passed 150 mesh	48.60%
Plasticity	Very good
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	10.53%
Volume drying shrinkage	30.76%
Tempering water	27.44%
Oxidation	Complete in 5 hours.
Maximum safe burning temperature	Cone 3
Heat range	Cone 02 to cone 3; bloats above cone 3; surface pits occur due to lime-iron granules; cracks in burning.
When burned at cone 3—	
Burning shrinkage	6.51%
Total shrinkage	17.04%
Porosity	2.71%
Fracture	Stony
Color	Light buff at cone 010; changes to greenish-gray at cone 03; scums.
Possibilities	Not desirable for manufacture of clay products because of cracking in burning, surface pitting, and scumming.

Sample 52.—Location in mine, NE. entry in sump; sample represents floor material from 12 to 36 inches below coal; similar to Sample 51, but contains less lime and iron carbonate granules.

Slaking test	Complete in 13 hours.
Residues left on screens—	
10 mesh	4.85%
20 mesh	9.00%
35 mesh	18.65%
65 mesh	12.20%
100 mesh	6.17%
150 mesh	7.33%
Passed 150 mesh	41.80%
Plasticity	Good
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	8.47%
Tempering water	23.70%
Oxidation	Complete in 5 hours.
Maximum safe burning temperature	Cone 3
Heat range	Cone 02 to cone 3; few surface pits occur; cracks in burning.

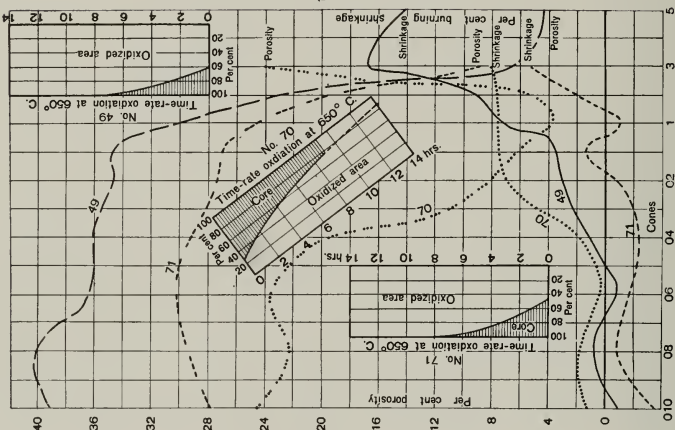


FIG. 26.—Graphic illustration of the laboratory tests of Samples 49, 70, and 71, floor materials in mine No. 1, Illinois Valley Coal Company, Sparland.

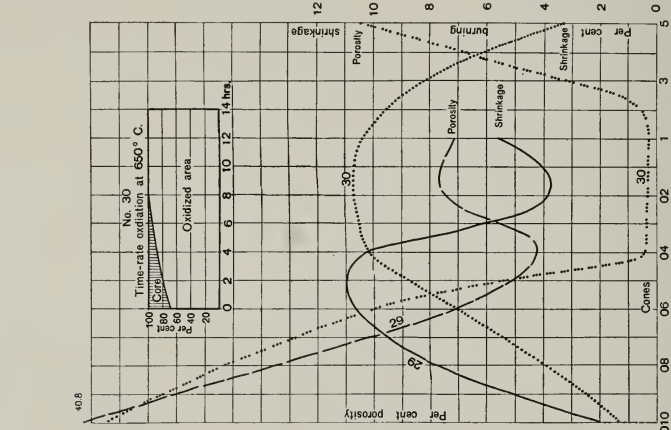


FIG. 25.—Graphic illustration of the laboratory tests of Samples 29 and 30, roof materials in mine No. 1, Illinois Valley Coal Company, Sparland.

When burned at cone 3—
- Burning shrinkage 5.25%
- Total shrinkage 13.72%
- Porosity 8.07%
- Fracture ..... Stony
- Color....Buff at 010, changes to greenish-gray at cone 03; scums.

Possibilities .....Not a desirable clay because of cracking, pitting, and scumming.

ILLINOIS VALLEY COAL COMPANY, MINE NO. 1, SPARLAND

(See figures 25 and 26)

Depth of shaft—30 feet.

Coal bed—No. 7.

Thickness of floor—25 feet in places.

Sample 29.—Outcrop of roof of coal; sample represents roof material up to 30 inches above coal; mixture of fragments of hard, dark-blue and black shale high in finely divided carbon; contains calcium-iron carbonate concretions.

Section of material sampled—
4. Shale, soft ..... 6 inches
3. Shale, black ..... 16 inches
2. Shale, gray ..... 6 inches
1. Shale, black ..... 12 inches

Slaking test .....Slakes very imperfectly.

Residues left on screens—
- 10 mesh 83.00%
- 20 mesh 4.10%
- 35 mesh 3.73%
- 65 mesh 2.55%
- 100 mesh 1.08%
- 150 mesh 0.60%
- Passed 150 mesh 4.94%

Plasticity ..... Low

Molding properties ..... Fair

Drying properties ..... Warps
- Linear drying shrinkage 5.21%
- Tempering water 22.70%

Oxidation .....No trials made.

Maximum safe burning temperature.....Cone 04

Heat range.....Very short; surface pits due to calcium-iron granules; bloats above cone 04.

When burned at cone 04—
- Burning shrinkage 10.90%
- Total shrinkage 16.11%
- Porosity 8.17%
- Fracture .....Vitreous
- Color.....Light cherry red; free from scum.

Possibilities .....A very unsuitable material, as it warps in drying, has short heat range, pits, and is sensitive to firing.

Sample 30.—Outcrop of roof of coal; sample represents roof material from 30 to 66 inches above coal; soft, weathered, yellow shale in small fragments; contains carbonaceous matter, gives test for calcium sulphate.

Slaking test ..... Showed no evidence of slaking.
Residues left on screen ..... All on 10-mesh screen.
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
  Linear drying shrinkage 2.91%
  Tempering water 26.10%
Oxidation ..... Complete in 8 hours.
Maximum safe burning temperature ..... Cone 1
Heat range ..... Good, cone 04 to cone 1; bloats above cone 1.
When burned at cone 1—
  Burning shrinkage 10.37%
  Total shrinkage 13.64%
  Porosity 0.45%
  Fracture ..... Vitreous
  Color ..... Dark red; slightly scummed.
Possibilities ..... Common and face brick, hollow ware.

Sample 49.—Outcrop of floor clay of coal No. 6; sample represents floor material from 18 to 78 inches below coal, first 18 inches was discarded because of being black and colored with iron; medium hard, light-gray clay, highly calcareous; contains numerous small nodules of calcium carbonate and carbonaceous matter as plant fossils.

Slaking test ..... Slakes rather imperfectly.
Residues left on screens—
  10 mesh 83.90%
  20 mesh 6.75%
  35 mesh 2.95%
  65 mesh 1.64%
  100 mesh 0.65%
  150 mesh 0.32%
  Passed 150 mesh 3.79%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
  Linear drying shrinkage 5.92%
  Tempering water 20.30%
Oxidation ..... Completely oxidized in 7 hours.
Maximum safe burning temperature ..... Cone 1
Heat range ..... Short; cracks in burning; serious surface pitting occurs, due to lime granules.
When burned at cone 1—
  Burning shrinkage 3.61%
  Total shrinkage 9.53%
  Porosity 29.98%
  Fracture ..... Stony
  Color ..... Light red at cone 010, changes abruptly to dark buff at cone 03, and to a light buff at cone 3.
Possibilities ..... A very unsuitable material as it has short heat range, cracks in burning, pits, and is sensitive to overfiring.

Sample 70.—Outcrop of floor clay of coal No. 6; sample represents floor material from 0 to 36 inches below coal; this material had been wet and was partly slaked; calcareous; contains nodules of calcium carbonate, iron carbonate, and carbonaceous matter.

Slaking test ..... Slaked in 159 hours.
Residues left on screens—
10 mesh 1.92%
20 mesh 4.58%
35 mesh 12.95%
65 mesh 18.52%
100 mesh 9.76%
150 mesh 4.78%
Passed 150 mesh 47.49%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 8.30%
Volume drying shrinkage 24.80%
Tempering water 25.50%
Oxidation ..... Difficult, 77% oxidized in 9 hours.
Maximum safe burning temperature ..... Cone 1
Heat range ..... Cone 02 to cone 1; surface pits; cracks in burning; bloats above cone 1.
When burned at cone 1—
Burning shrinkage 3.79%
Total shrinkage 12.09%
Porosity 3.79%
Fracture ..... Stony
Color ..... Buff at cone 010, pale red at 08, and brown at 02.
Possibilities ..... Valueless for clay products, as it is difficult to oxidize, cracks in burning, pits at the surface, and is sensitive to overfiring.

Sample 71.—From same location as Sample 70; represents floor clay from 36 to 108 inches below coal; similar to Sample 70, but is more calcareous.

Slaking test ..... Slakes in 51 hours.
Residues left on screens—
10 mesh 11.60%
20 mesh 11.35%
35 mesh 10.86%
65 mesh 7.51%
100 mesh 4.15%
150 mesh 2.18%
Passed 150 mesh 52.35%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Cracks
Linear drying shrinkage 15.56%
Tempering water 24.30%
Oxidation ..... Complete in 8 hours.
Maximum safe burning temperature ..... Cone 3
Heat range ..... Very short; bloats above cone 3; cracks in burning; surface pits due to lime granules.

When burned at cone 3—
- Burning shrinkage 2.66%
- Total shrinkage 18.22%
- Porosity 8.93%
- Fracture ..... Stony
- Color ..... Light salmon at cone 010 to pale red at 08 to brown at 2; scums excessively.

Possibilities ..... Valueless for clay products, as it cracks in drying and in burning; has short heat range; is sensitive to bloating, pits, and scums.

WENONA COAL COMPANY, WENONA MINE, WENONA

(See figure 27)

Depth of shaft—567 feet.

Coal bed—No. 2.

Sample 15.—Sent by company; represents roof material of coal; hard, dark-gray massive shale; breaks with conchoidal fracture, apparently free from carbonaceous matter and concretions.

Slaking test..... Apparently does not slake to any appreciable extent.

Residues left on screens—
- 10 mesh 99.70%
- 20 mesh 0.10%
- 60 mesh 0.10%
- 100 mesh 0.00%
- 120 mesh 0.00%
- Passed 120 mesh 0.10%

Plasticity ..... Low

Molding..... Tends to tear a little in molding, though not badly.

Drying properties ..... Good
- Linear drying shrinkage 4.44%
- Volume drying shrinkage 15.01%
- Tempering water 21.20%

Oxidation ..... Complete in 4 hours.

Maximum safe burning temperature ..... Above cone 3

Heat range ..... Cone 01 to above cone 3.

When burned at cone 3—
- Burning shrinkage 8.75%
- Total shrinkage 13.19%
- Porosity 0.40%
- Fracture ..... Dull, smooth.
- Color ..... Dark cherry red, free from scum.

Possibilities ..... Common, front, and paving brick

Precautions ..... Fine grinding and thorough tempering would improve the molding properties; the addition of a small amount of suitable plastic clay would be beneficial.

Sample 18.—Sent by company; represents floor material of coal; hard, light-gray shale; contains carbonaceous matter as plant fossils and a trace of calcium sulphate, no concretions visible.

Slaking test ..... Slakes in 7 days.

Residues left on screens—
- 10 mesh 2.45%
- 20 mesh 5.80%
- 60 mesh 5.90%
- 100 mesh 0.88%
- 120 mesh 0.49%
- Passed 120 mesh 84.48%

Plasticity	Fair
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	5.04%
Volume drying shrinkage	15.78%
Tempering water	19.77%
Oxidation	Complete in 5 hours.
Maximum safe burning temperature	Above cone 3.

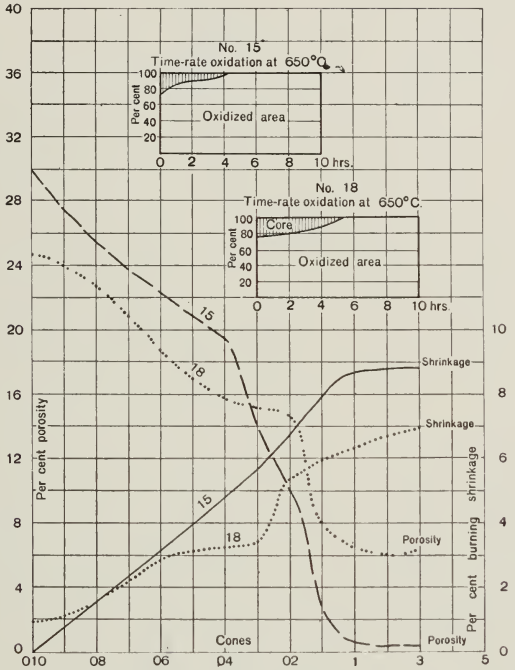


FIG. 27.—Graphic illustration of the laboratory tests of Sample 15, roof material, and Sample 18, floor material, in Wenona mine, Wenona Coal Company, Wenona.

Heat range	Cone 1 to above cone 3.
When burned at cone 3—	
Burning shrinkage	6.92%
Total shrinkage	11.96%
Porosity	6.30%
Fracture	Stony
Color	Light red at cone 010, gradually changes to medium red at cone 3.
Possibilities	Common, front, and paving brick, hollow ware.

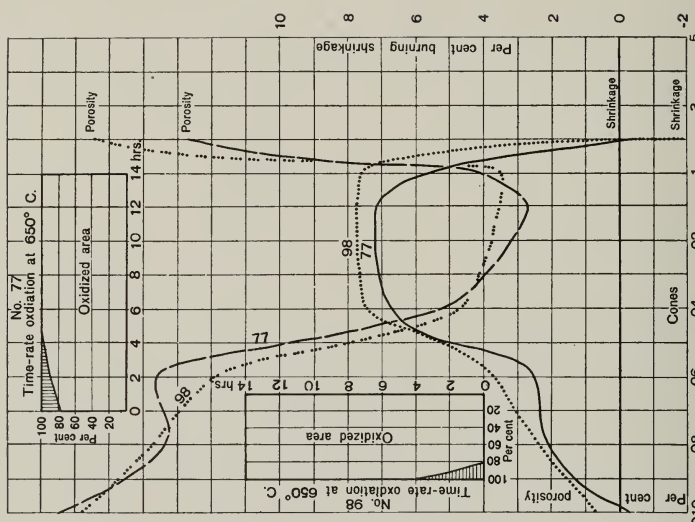


FIG. 29.—Graphic illustration of the laboratory tests of Samples 77 and 98, roof materials in mine No. 2, Minonk Coal Company, Minonk.

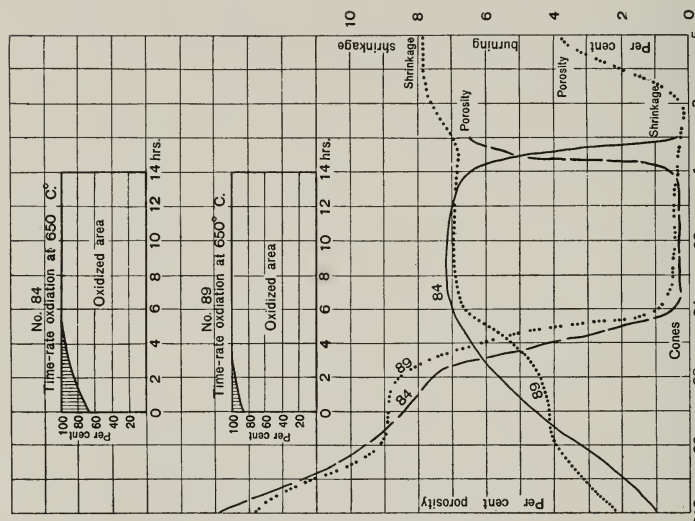


FIG. 28.—Graphic illustration of the laboratory tests of Samples 84 and 89, floor materials in mine No. 2, Minonk Coal Company, Minonk.

MINONK COAL COMPANY, MINE NO. 2, MINONK

(See figures 28 and 29)

Depth of shaft—540 feet.

Coal bed—No. 2.

Thickness of floor—6 inches to 4 feet.

Thickness of roof—15 to 20 feet.

Sample 84.—Location in mine, NW. 4th W.; sample represents floor material from 2 to 26 inches below coal (the material sampled is all removed in mining); medium hard, light to dark-blue gray clay; shows well-developed slickensides; contains carbonaceous matter and a trace of calcium sulphate.

Slaking test	Incompletely slaked at end of test.
Residues left on screens—	
10 mesh	10.45%
20 mesh	9.66%
35 mesh	16.50%
65 mesh	13.65%
100 mesh	5.95%
150 mesh	2.44%
Passed 150 mesh	41.81%
Plasticity	Fair
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	5.95%
Volume drying shrinkage	17.30%
Tempering water	20.00%
Oxidation	Complete in 5 hours.
Maximum safe burning temperature	Cone 1
Heat range	Cone 04 to cone 1; bloats above cone 1.
When burned at cone 1—	
Burning shrinkage	6.54%
Total shrinkage	12.49%
Porosity	0.72%
Fracture	Vitreous
Color	Light brown; scums a little.
Possibilities	Common and front brick; hollow ware.

Sample 89.—Location in mine, NW. of shaft; sample represents floor material from 2 to 24 inches below coal No. 2; medium hard, gray clay; structure resembles that of fire clay; shows well-developed slickensides; contains carbonaceous matter as plant fossils and occasional brown iron stains; gives test for calcium sulphate.

Slaking test	Incomplete at end of test.
Residues left on screens—	
10 mesh	15.67%
20 mesh	10.50%
35 mesh	15.23%
65 mesh	12.84%
100 mesh	5.09%
150 mesh	2.29%
Passed 150 mesh	38.38%
Plasticity	Good
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	5.35%
Tempering water	21.60%
Oxidation	Complete in 3 hours.

Maximum safe burning temperature..... Cone 3
Heat range.....Cone 04 to cone 3; bloats above cone 3.
When burned at cone 3—
Burning shrinkage 7.67%
Total shrinkage 13.02%
Porosity 0.25%
Fracture .....Vitreous
Color...Salmon at cone 010, pale red at cone 04, brown at cone 3.
Possibilities.....Common and front brick, hollow ware.

Sample 77.—Location in mine, N. 14 W.; sample represents roof material up to 24 inches above coal; impurities are sulphur balls and thin layers of coal; medium hard, dark-gray, sandy micaceous shale; contains hard clay concretions stained brown with iron oxide.

Slaking test .....No apparent slaking action noted.
Residues left on screen.....All on 10-mesh screen.
Plasticity ..... Low
Molding properties ..... Fair
Drying properties ..... Good
Linear drying shrinkage 3.49%
Tempering water 18.60%
Oxidation .....Complete in 5 hours.
Maximum safe burning temperature.....Cone 01
Heat range.....Cone 04 to cone 01; bloats above cone 01.
When burned at cone 01—
Burning shrinkage 7.13%
Total shrinkage 10.62%
Porosity 5.42%
Fracture .....Dense, stony.
Color .....Dark cherry red; scums slightly.
Possibilities .....Common and front brick.

Sample 98.—Location in mine, straight north, main entry; sample represents roof material up to 4 feet above coal; impurities are sulphur balls and thin layers of coal; medium hard, gray sandy shale; contains hard, clay-like concretions with an outer shell and pyrite particles scattered throughout, also some carbonaceous matter as plant fossils; shows test for calcium sulphate.

Slaking test .....Apparently devoid of slaking.
Residues left on screen.....All on 10-mesh screen.
Plasticity ..... Low
Molding properties .....Molded without serious trouble, though there was a tendency to tear at corners on issuing from the die.
Drying properties ..... Good
Linear drying shrinkage 2.83%
Tempering water 18.20%
Oxidation .....Complete in 4 hours.
Maximum safe burning temperature..... Cone 1
Heat range .....Cone 04 to cone 1; very sensitive to bloating above cone 1.
When burned at cone 1—
Burning shrinkage 7.69%
Total shrinkage 10.52%
Porosity 6.97%
Fracture .....Dense, stony.
Color .....Dark cherry red; scums slightly.
Possibilities .....Common and front brick.

Precautions ..... Should be thoroughly tempered in order to develop sufficient plasticity for molding, and should be burned at a safe temperature below that at which bloating occurs.

COLCHESTER COAL & MANUFACTURING COMPANY, COLCHESTER

(See figure 30)

Coal bed—No. 2.

Thickness of roof—Reported to be 10 to 30 feet.

Sample 5.—Represents roof material of coal; hard, gray shale; contains carbonaceous matter as plant fossils, otherwise rather uniform in appearance.

Slaking test ..... Breaks up into few coarse fragments.
Residues left on screen ..... All on 10-mesh screen.
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 4.71%
Volume drying shrinkage 13.96%
Tempering water 18.92%
Oxidation ..... Oxidizes readily, complete in 2 hours.
Maximum safe burning temperature ..... Above cone 3
Heat range... Temperature not carried high enough to determine this.
When burned at cone 3—
Burning shrinkage 9.80%
Total shrinkage 14.51%
Porosity 0.24%
Fracture ..... Stony
Color... Medium red at cone 1, dark red at cone 3; scums slightly.
Possibilities ..... Common, front, and paving brick, hollow ware.
Precautions ..... For hollow ware the shale would require thorough tempering to develop good working plasticity.

VALENTINE FARM MINE, COLCHESTER

(See figure 31)

Coal bed—No. 2.

Sample 37.—Sample represents floor material below coal; medium hard, dense fire clay; contains occasional small hard, clay-like granules; comparatively free from carbon.

Slaking test ..... Breaks down in 13 hours.
Residues left on screens—
10 mesh 3.55%
20 mesh 11.61%
35 mesh 15.02%
65 mesh 12.66%
100 mesh 5.24%
150 mesh 2.21%
Passed 150 mesh 49.71%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 6.53%
Tempering water 16.70%

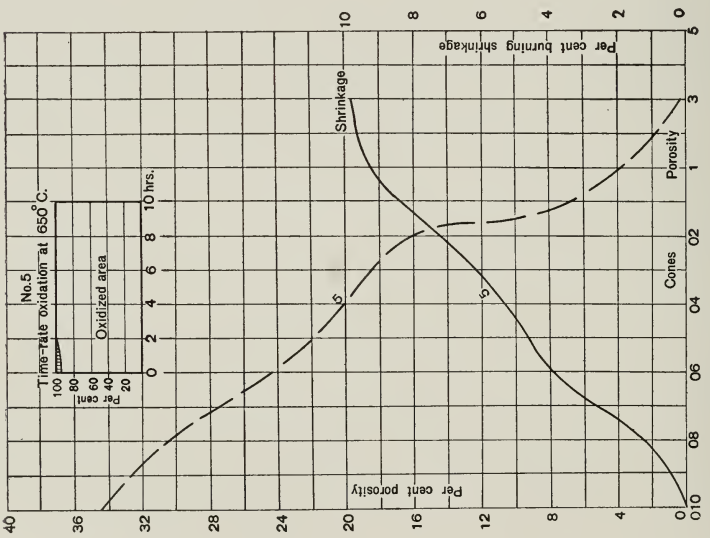


FIG. 30.—Graphic illustration of the laboratory tests of Sample 5, roof material in the mine of Colchester Coal & Manufacturing Company, Colchester.

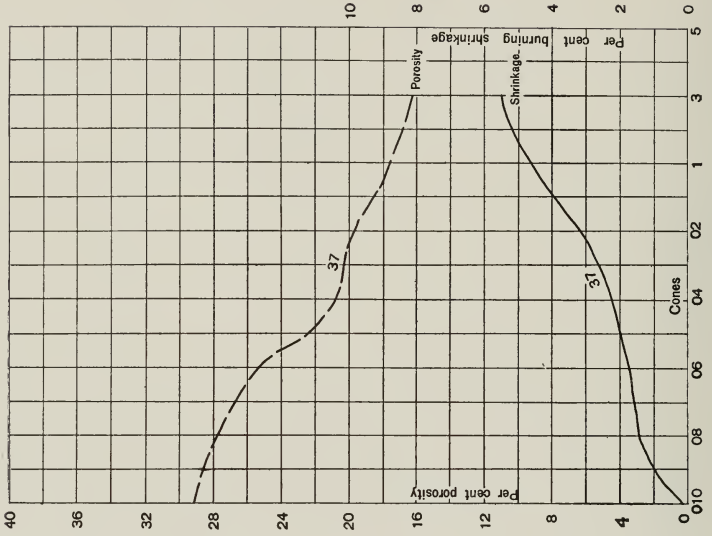


FIG. 31.—Graphic illustration of the laboratory tests of Sample 37, floor material in Valentine Farm mine, Colchester.

Oxidation .....No oxidizing trials made since the clay remains highly porous at temperatures considerably above 900°C; no serious difficulty would be encountered during the oxidation stage.

Maximum safe burning temperature.....Probably above cone 8

Heat range.....Very broad; fusion temperature cone 29 (1710°C).

When burned at cone 3—

Burning shrinkage	5.46%
Total shrinkage	11.99%
Porosity	16.30%
Fracture	Stony
Color	Light buff.

Possibilities .....Common and front brick, enamel brick, architectural terra cotta, fireproofing, and as a bond for No. 2 fire brick; its use for stoneware is doubtful.

ALDEN COAL COMPANY, MINE NO. 7, MATHERVILLE

(See figures 32 and 33)

Depth of shaft—95 feet.

Area mined—10 acres.

Coal bed—No. 1.

Sample 34.—Represents floor material below coal; a mixture of light, blue-gray, sandy shale and a very dark almost black shale with a structure resembling that of fire clay; contains carbon and lime-iron concretions.

Slaking test .....Slakes in 15 hours.

Residues left on screens—

10 mesh	56.80%
20 mesh	8.54%
35 mesh	10.35%
65 mesh	7.37%
100 mesh	2.41%
150 mesh	1.29%
Passed 150 mesh	13.23%

Plasticity ..... Low

Molding properties.....Molds with difficulty; tears at corners of die.

Drying properties ..... Good

Linear drying shrinkage	4.44%
Volume drying shrinkage	13.50%
Tempering water	19.30%

Oxidation .....Complete in 10 hours.

Maximum safe burning temperature.....Above cone 5

Heat range .....Temperature not carried high enough to determine this; surface pits due to lime-iron granules.

When burned at cone 5—

Burning shrinkage	7.19%
Total shrinkage	11.63%
Porosity	13.05%
Fracture	Stony
Color	Salmon at cone 010, dull red at cone 03, brownish-gray at cone 5.

Possibilities .....Common and front brick.

Precautions .....Works with difficulty in the die; the addition of a more plastic clay and less of the sandy part would be an improvement.

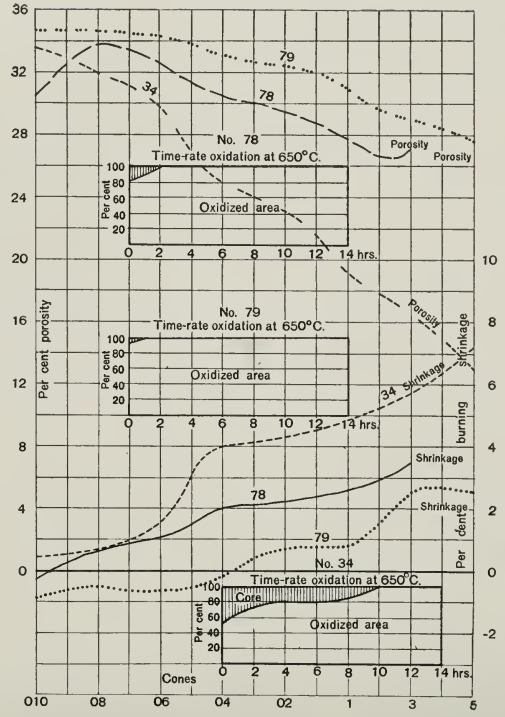


FIG. 32.—Graphic illustration of the laboratory tests of Samples 34, 78, and 79, floor materials in mine No. 7, Alden Coal Company, Matherville.

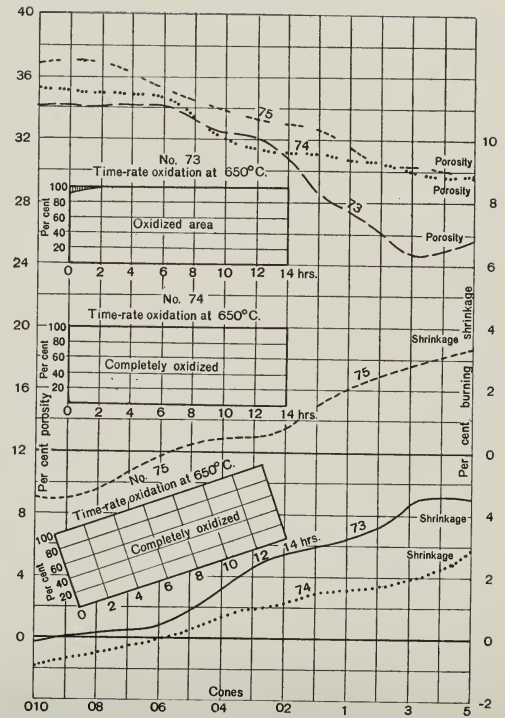


FIG. 33.—Graphic illustration of the laboratory tests of Samples 73, 74, and 75, floor materials in mine No. 7, Alden Coal Company, Matherville.

Sample 78.—Location in mine, 4th N. entry on W. side; sample represents floor material from 0 to 30 inches below coal; light-gray, decidedly sandy clay streaked with yellow; contains streaks of carbonaceous matter, mica flakes, and sulphate of iron.

Slaking test ..... Imperfectly slaked at end of test.
Residues left on screens..... Practically all on 10-mesh screen.
Plasticity ..... Low
Molding properties ..... Molds with difficulty.
Drying properties..... Dries with heavy scum of iron sulphate.
Linear drying shrinkage..... 2.62%
Tempering water 11.96%
Oxidation ..... Complete in 2 hours.
Maximum safe burning temperature..... Above cone 3
Heat range... Temperature not carried high enough to determine this.
When burned at cone 3—
Burning shrinkage 3.45%
Total shrinkage 6.07%
Porosity 26.96%
Fracture ..... Stony
Color..... Dark velvet-red surface, salmon-color fracture.
Possibilities..... Doubtful on account of difficulties in molding.

Sample 79.—Location in mine, same as Sample 78; sample represents floor material from 30 to 63 inches below coal; clay similar to Sample 78 except it does not show iron sulphate.

Slaking test..... Imperfectly slaked at end of test.
Residues left on screens—
10 mesh 45.32%
20 mesh 7.50%
35 mesh 8.18%
65 mesh 9.05%
100 mesh 7.07%
150 mesh 3.98%
Passed 150 mesh 18.90%
Plasticity ..... Low
Molding properties..... Tears a little at corners on issuing from die.
Drying properties ..... Good
Linear drying shrinkage 2.69%
Tempering water 17.40%
Oxidation ..... Complete in 1 hour.
Maximum safe burning temperature..... Above cone 5
Heat range... Temperature not carried high enough to determine this.
When burned at cone 5—
Burning shrinkage 2.61%
Total shrinkage 5.30%
Porosity 27.59%
Fracture ..... Stony
Color ..... Buff
Possibilities..... Doubtful because of difficulties in molding.

Sample 73.—Location in mine, west of shaft bottom; represents floor material from 0 to 16 inches below coal; medium hard, light-gray, sandy clay with yellow streaks; contains streaks of carbonaceous matter and salts of iron sulphate.

Slaking test ..... Slakes slowly and imperfectly.
Residues left on screens—
10 mesh 35.83%
20 mesh 5.12%
35 mesh 9.32%
65 mesh 8.48%
100 mesh 5.88%
150 mesh 3.70%
Passed 150 mesh 31.67%
Plasticity ..... Low
Molding properties ..... Though the plasticity is low, the clay molded without serious trouble.
Drying properties ..... Good; has a surface scum of iron sulphate.
Linear drying shrinkage 3.20%
Tempering water 17.30%
Oxidation ..... Complete in 2 hours.
Maximum safe burning temperature ..... Above cone 5
Heat range ..... Burning temperature not carried high enough to determine the range; iron sulphate is converted to the ferric oxide, giving a dark velvet-red surface.
When burned at cone 5—
Burning shrinkage 4.44%
Total shrinkage 7.64%
Porosity 25.75%
Fracture ..... Stony
Color ..... Dark velvet-red surface, whereas a fracture shows salmon color.
Possibilities ..... Common and front brick.

Sample 74.—Same location in mine as Sample 73; sample represents floor material from 16 to 38 inches below coal; decidedly sandy, light-gray, dark-gray, and yellow-banded clay; contains streaks of carbonaceous matter, numerous mica flakes, and iron sulphate.

Slaking test ..... Only slight slaking action.
Residues left on screens—
10 mesh 57.50%
20 mesh 1.43%
35 mesh 4.67%
65 mesh 8.21%
100 mesh 6.18%
150 mesh 3.87%
Passed 150 mesh 18.14%
Plasticity ..... Low
Molding properties ..... Cracks at corners on issuing from the die.
Drying properties ..... Dries with scum of iron sulphate.
Linear drying shrinkage 2.51%
Volume drying shrinkage 7.89%
Tempering water 18.74%
Oxidation ..... Complete when first trial was drawn.
Maximum safe burning temperature ..... Above cone 5
Heat range ..... Burning temperature not carried high enough to determine heat range; iron sulphate is converted to ferric oxide in burning.

When burned at cone 5—
- Burning shrinkage 2.84%
- Total shrinkage 5.35%
- Porosity 29.69%
- Fracture ..... Stony
- Color.....Dark velvet-red surface, light-red fracture.

Possibilities.....Doubtful, difficult to mold in the die.

Sample 75.—Same location in the mine as Samples 73 and 74; sample represents floor material from 38 to 61 inches below coal; clay similar in appearance to Sample 73.

Slaking test .....Slakes slowly and imperfectly.

Residues left on screens—
- 10 mesh 85.90%
- 20 mesh 1.85%
- 35 mesh 2.46%
- 65 mesh 2.61%
- 100 mesh 1.33%
- 150 mesh 0.90%
- Passed 150 mesh 4.95%

Plasticity ..... Low

Molding properties.....Molds with difficulty, cracks at the corners.

Drying properties.....Dries with thin scum of iron sulphate.
- Linear drying shrinkage 2.42%
- Tempering water 17.30%

Oxidation .....Complete when first trial was drawn.

Maximum safe burning temperature.....Above cone 5

Heat range .....Burning temperature not carried high enough to determine this.

When burned at cone 5—
- Burning shrinkage 3.30%
- Total shrinkage 5.72%
- Porosity 29.63%
- Fracture ..... Stony
- Color.....Dark velvet-red surface, medium red fracture.

Possibilities .....Doubtful, difficult to mold.

PRYCE COAL COMPANY, COAL VALLEY

(See figure 34)

Depth of shaft—122 feet.

Area mined—10 to 12 acres.

Coal bed—No. 1.

Sample 43.—Location of sample, south of shaft; sample represents floor material from 4 to 18 inches below coal; sample had become wet and slaked; light-gray, sandy clay; contains streaks of iron, a conspicuous amount of iron sulphate crystals, and fragments of coal.

Slaking test.....Slakes readily but rather incompletely.

Residues left on screens—
- 10 mesh 2.52%
- 20 mesh 6.91%
- 35 mesh 14.44%
- 65 mesh 15.55%
- 100 mesh 11.87%
- 150 mesh 4.93%
- Passed 150 mesh 43.78%
- Plasticity ..... Low

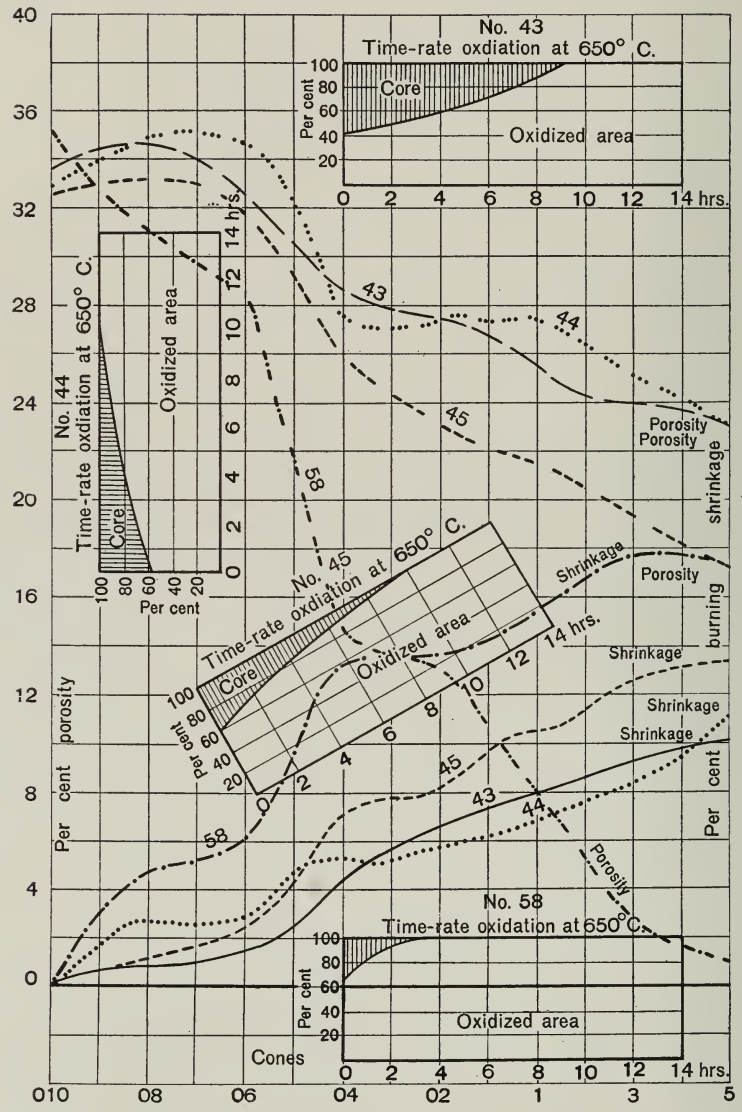


Fig. 34.—Graphic illustration of the laboratory tests of Samples 43, 44, 45, and 58, floor materials in mine of Pryce Coal Company, Coal Valley.

Molding properties ..... Fair
Drying properties .....Dries safely with heavy coating of sulphate of iron.
Linear drying shrinkage..... 5.40%
Tempering water 17.70%
Oxidation .....Complete in 9 hours.
Maximum safe burning temperature.....Considerably above cone 5
Heat range .....Apparently good; during burning the iron sulphate is converted to ferric oxide giving a rich red surface.
When burned at cone 5—
Burning shrinkage 5.08%
Total shrinkage 10.48%
Porosity 23.22%
Fracture ..... Stony
Color .....Dark velvet-red.
Possibilities .....Common and front brick.

Sample 44.—Location in mine, same as Sample 43; sample represents floor material from 18 to 32 inches below coal; clay appears to be same as Sample 43 except that it contains fewer fragments of coal.

Slaking test .....Slakes readily though rather incompletely.
Residues left on screens—
10 mesh 1.20%
20 mesh 0.91%
35 mesh 3.55%
65 mesh 19.58%
100 mesh 9.58%
150 mesh 7.64%
Passed 150 mesh 57.54%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties .....Dries safely; heavy scum of iron sulphate on surface.
Linear drying shrinkage 4.52%
Volume drying shrinkage 13.00%
Tempering water 18.05%
Oxidation .....Complete in 10 hours.
Maximum safe burning temperature.....Above cone 5
Heat range .....Apparently good; iron sulphate is converted into ferric oxide during burning.
When burned at cone 5—
Burning shrinkage 5.46%
Total shrinkage 9.98%
Porosity 23.23%
Fracture ..... Stony
Color .....Dark velvet-red.
Possibilities .....Common and front brick.

Sample 45.—Location in mine, same as Samples 43 and 44; sample represents floor material from 32 to 48 inches below coal; clay very similar to Samples 43 and 44 in appearance, though darker in color.

Slaking test.....Slakes readily but rather incompletely.

Residues left on screens—
- 10 mesh 3.05%
- 20 mesh 5.06%
- 35 mesh 11.34%
- 65 mesh 17.40%
- 100 mesh 8.30%
- 150 mesh 5.36%
- Passed 150 mesh 49.49%

Plasticity ..... Fair

Molding properties ..... Molds without difficulty.

Drying properties ..... Good; surface scums with iron sulphate.
- Linear drying shrinkage 4.62%
- Volume drying shrinkage 13.80%
- Tempering water 18.60%

Oxidation ..... Complete in 10 hours.

Maximum safe burning temperature ..... Above cone 5

Heat range ..... Apparently good; iron sulphate changed to ferric oxide in burning.

When burned at cone 5—
- Burning shrinkage 6.63%
- Total shrinkage 11.25%
- Porosity 17.23%
- Fracture ..... Stony
- Color ..... Dark velvet-red.

Possibilities ..... Common and front brick.

Sample 58.—Location in mine, 150 yards southeast of shaft; sample represents floor material from 8 to 20 inches below coal; light-gray clay increasingly sandy with depth; contains occasional fragments of coal and granules of lime-iron carbonate.

Slaking test ..... Slakes in 11 hours.

Residues left on screens—
- 10 mesh 7.37%
- 20 mesh 4.59%
- 35 mesh 21.40%
- 65 mesh 19.96%
- 100 mesh 6.95%
- 150 mesh 5.16%
- Passed 150 mesh 34.57%

Plasticity ..... Good

Molding properties ..... Good

Drying properties ..... Good
- Linear drying shrinkage 5.35%
- Volume drying shrinkage 17.40%
- Tempering water 23.00%

Oxidation ..... Complete in 3 hours.

Maximum safe burning temperature ..... Above cone 5

Heat range ..... Cone 04 to above cone 5; occasional surface pits occur due to lime-iron granules.

When burned at cone 5—
- Burning shrinkage 8.60%
- Total shrinkage 13.95%
- Porosity 1.04%
- Fracture ..... Dense, stony.
- Color ..... Light buff at cone 010, changes abruptly to light brown at cone 04, and remains constant to cone 5.

Possibilities ..... Common and front brick, fireproofing, hollow ware.

MANUFACTURERS & CONSUMERS COAL COMPANY, MINE NO. 1, DECATUR

(See figure 35)

Depth of shaft—575 feet.

Coal bed—No. 5.

Thickness of roof—Irregular.

Thickness of floor—About 4 feet.

Sample 69.—Location in mine, main W. 2,450 feet; sample represents roof material from 26 to 68 inches above coal; medium hard, calcareous, mottled light-brown and gray shale; contains hard clay concretions, fine pyrite grains, iron carbonate, and gypsum.

Slaking test	Slakes imperfectly.
Residues left on screens—	
10 mesh	47.60%
20 mesh	11.00%
35 mesh	9.02%
65 mesh	5.71%
100 mesh	2.21%
150 mesh	1.29%
Passed 150 mesh	23.17%
Plasticity	Medium
Molding properties	Fair
Drying properties	Warps
Linear drying shrinkage	6.85%
Volume drying shrinkage	19.56%
Tempering water	27.60%
Oxidation	Complete in 6 hours.
Maximum safe burning temperature	Cone 04
Heat range	Cone 06 to cone 04; surface pits; bloats above cone 04.
When burned at cone 04—	
Burning shrinkage	6.73%
Total shrinkage	13.58%
Porosity	0.47%
Fracture	Vitreous
Color	Medium red; scums badly
Possibilities	Common brick; its use for hollow blocks is doubtful because of warping.

Sample 93.—Location in mine, 100 feet from air shaft; sample represents floor material from 24 to 48 inches below coal; material had been slaked; light-gray clay streaked with dark gray and yellow; contains partly decomposed pyrite, gypsum, and free sulphur; very little carbonaceous matter visible.

Slaking test	Slakes in 159 hours.
Residues left on screens—	
10 mesh	7.36%
20 mesh	1.52%
35 mesh	3.10%
65 mesh	9.03%
100 mesh	5.82%
150 mesh	2.78%
Passed 150 mesh	70.39%
Plasticity	Good
Molding properties	Good

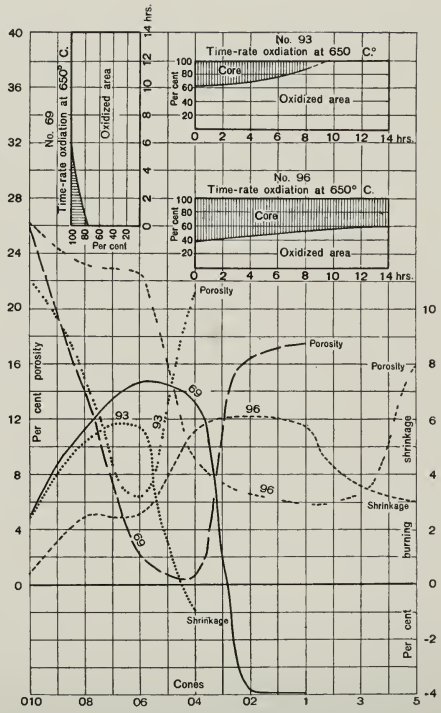


FIG. 35.—Graphic illustration of the laboratory tests of Sample 69, roof material, and Samples 93 and 96, floor materials, in mine No. 1, Manufacturers & Consumers Coal Company, Decatur.

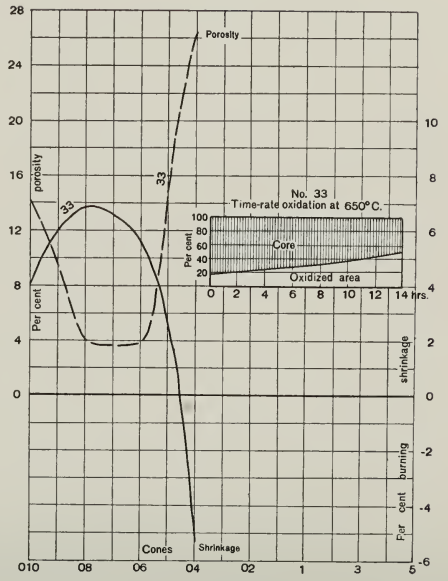


FIG. 36.—Graphic illustration of the laboratory tests of Sample 33, floor material in Niantic mine, Decatur Coal Company, Niantic.

Drying properties ..... Good; scums
Linear drying shrinkage 9.30%
Tempering water 27.30%
Oxidation ..... Complete in 9 hours
Maximum safe burning temperature ..... Cone 06
Heat range ..... Very short; cracks in burning; bloats above cone 06.
When burned at cone 06—
Burning shrinkage 5.80%
Total shrinkage 15.10%
Porosity 6.31%
Fracture ..... Vitreous
Color ..... Dull, medium red; scums.
Possibilities ..... A very unsuitable material as it has short heat range, cracks in burning, and is sensitive to overfiring and bloating.

Sample 96.—Location in mine, 8th S. off main W.; sample represents floor material from 8 to 24 inches below coal; medium hard, gray clay stained brown in streaks; structure is that of fire clay; contains occasional carbonate of iron granules and carbonaceous matter as plant fossils.

Slaking test ..... Slakes in 9 hours.
Residues left on screens—
10 mesh 1.53%
20 mesh 0.40%
35 mesh 0.50%
65 mesh 0.65%
100 mesh 0.52%
150 mesh 0.37%
Passed 150 mesh 96.03%
Plasticity ..... High
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 9.74%
Tempering water 20.40%
Oxidation ..... Difficult; 58% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 1
Heat range ..... Cone 04 to cone 1; occasional surface pits occur; bloats above cone 1.
When burned at cone 1—
Burning shrinkage 5.77%
Total shrinkage 15.51%
Porosity 5.93%
Fracture ..... Dense, stony
Color ..... Buff at cone 08, to gray brown at cone 04, color constant to cone 1.
Possibilities ..... Common and front brick, hollow blocks, and fireproofing.
Precautions ..... Care must be taken during the oxidation period in burning.

DECATUR COAL COMPANY, NIANTIC MINE, NIANTIC

(See figure 36)

Depth of shaft—612 feet.

Coal bed—No. 5.

Sample 33.—Sent by company; sample represents 36 inches of floor clay; medium soft, calcareous, light-gray shale stained brown in spots; contains carbonaceous matter as plant fossils and nodules of calcium-iron carbonate.

Slaking test	Slakes in 15 hours.
Residues left on screens—	
10 mesh	3.03%
20 mesh	5.20%
35 mesh	7.69%
65 mesh	5.24%
100 mesh	0.84%
150 mesh	0.90%
Passed 150 mesh	77.10%
Plasticity	Good
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	8.84%
Tempering water	18.40%
Oxidation	Difficult, 52% oxidized in 14 hours.
Heat range	Very short; bloats above cone 08; at cone 04 trial pieces are 10% larger than before burning; surface pits.
When burned at cone 08—	
Burning shrinkage	6.80%
Total shrinkage	15.64%
Porosity	3.98%
Fracture	Stony
Color	Dull red
Possibilities	An unsafe material, as it is difficult to oxidize, has high lime content and short heat range, pits, and is sensitive to bloating.

McLEAN COUNTY COAL COMPANY, McLEAN MINE, BLOOMINGTON

(See figures 37 and 38)

Depth of shaft—530 feet to coal No. 2; 400 feet to coal No. 5.

Coal beds—No. 2 and No. 5.

Thickness of roof of coal No. 2—Varies from 0 to 15 feet.

Thickness of floor of coal No. 2—More than 9 feet is known.

About 60 tons of shale is being mixed daily with 30 tons of burned dump for manufacture of 30,000 brick; for building tile, only shale is used.

Sample 59.—Location in mine, 1st S. on straight W.; sample represents roof material from 0 to 6 feet above coal No. 2; medium hard, light-gray shale streaked with brown stains; contains occasional hard, clay-like concretions.

Slaking test	Imperfectly slaked at end of test.
Residues left on screens—	
10 mesh	81.20%
20 mesh	7.62%
35 mesh	4.83%
65 mesh	2.39%
100 mesh	0.73%
150 mesh	0.30%
Passed 150 mesh	2.93%
Plasticity	Fair
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	4.89%
Volume drying shrinkage	16.40%
Tempering water	22.40%
Oxidation	Complete in 9 hours.
Maximum safe burning temperature	Cone 04
Heat range	Short; bloats above cone 04
When burned at cone 04—	
Burning shrinkage	7.42%
Total shrinkage	12.31%
Porosity	1.49%
Fracture	Vitreous
Color	Dull, light red at cone 06, dark red at cone 04.
Possibilities	Common brick, hollow ware.
Precautions	Must be completely oxidized below 90°C; owing to short heat range, considerable variation in shrinkage, porosity, and color of product from kiln would result.

Sample 66.—Location in mine, beginning of slope to upper coal; sample represents roof material from 9 feet 6 inches to 11 feet 6 inches above coal No. 2; medium hard, gray shale with occasional brown streaks; contains some finely distributed calcium carbonate.

Slaking test	No slaking action noticeable.
Residues left on screens—	
10 mesh	100.00%
Plasticity	Fair
Molding properties	Fair
Drying properties	Good
Linear drying shrinkage	3.04%
Tempering water	22.76%
Oxidation	Complete in 6 hours.

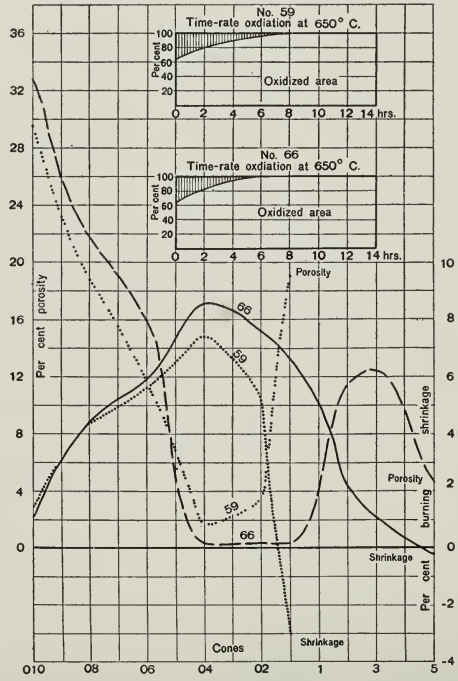


Fig. 37.—Graphic illustration of the laboratory tests of Samples 59 and 66, roof materials in McLean mine, McLean County Coal Company, Bloomington.

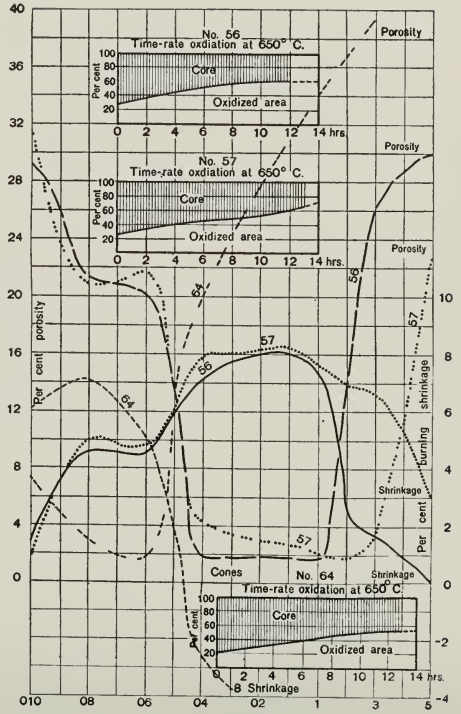


Fig. 38.—Graphic illustration of the laboratory tests of Samples 56, 57, and 64, floor materials in McLean mine, McLean County Coal Company, Bloomington.

Maximum safe burning temperature ..... Cone 04
When burned at cone 04—
Burning shrinkage 8.53%
Total shrinkage 11.57%
Porosity 0.36%
Fracture ..... Vitreous
Color ..... Cherry red; scums slightly.
Possibilities ..... Common and front brick.
Precautions ..... It would be necessary to burn the shale at a safe temperature below that at which bloating takes place; a product of variable shrinkage, porosity, and color would result.

Sample 56.—Location in mine, 7,000 feet straight N.; sample represents floor material from 12 to 28 inches below coal No. 2; medium hard, dark, slate-gray clay; contains gypsum, occasional lime concretions, and carbonaceous matter as plant fossils.

Slaking test ..... Slaking action ceases at the end of 27 hours.
Residues left on screens—
10 mesh 6.66%
20 mesh 4.37%
35 mesh 20.36%
65 mesh 25.43%
100 mesh 9.26%
150 mesh 4.76%
Passed 150 mesh 29.16%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 7.26%
Tempering water 22.16%
Oxidation ..... Difficult; 60% oxidized in 12 hours.
Maximum safe burning temperature ..... Cone 1
Heat range ..... Cone 04 to cone 1; bloats above cone 1; cracks.
When burned at cone 1—
Burning shrinkage 7.21%
Total shrinkage 14.47%
Porosity 1.78%
Fracture ..... Dense, stony
Color ..... Dull, reddish brown; scums slightly.
Possibilities ..... Not a safe material, as it is difficult to oxidize and tends to crack in burning.

Sample 57.—Location in mine, same as Sample 56; represents floor material from 28 to 46 inches below coal No. 2; very similar in appearance and working properties to previous sample.

Slaking test ..... Slakes in 13 hours.
Residues left on screens—
10 mesh 0.77%
20 mesh 3.04%
35 mesh 10.88%
65 mesh 39.80%
100 mesh 5.61%
150 mesh 6.41%
Passed 150 mesh 33.49%
Plasticity ..... Good
Molding properties ..... Good

Drying properties ..... Good
Linear drying shrinkage 7.29%
Volume drying shrinkage 22.80%
Tempering water 20.40%
Oxidation ..... Difficult, 66% oxidized in 13 hours.
Maximum safe burning temperature ..... Cone 1
Heat range ..... Cone 04 to cone 1; bloats above cone 1; tends to crack.
When burned at cone 1—
Burning shrinkage 7.55%
Total shrinkage 14.84%
Porosity 2.03%
Fracture ..... Dense, stony
Color ..... Dull reddish brown; scums slightly.
Possibilities ..... Not a safe material, as it is difficult to oxidize and tends to crack in burning.

Sample 64.—Location in mine, 300 feet E. of drop shaft; sample represents floor material from 4 to 30 inches below coal No. 5; a mixture of light-gray and blue shale; the light-gray shale is decidedly calcareous, the blue shale appears to be free from lime but contains carbon and streaks of pyrite and is stained brown in spots.

Slaking test ..... Slakes in 11 hours.
Residues left on screens—
10 mesh 3.20%
20 mesh 6.57%
35 mesh 14.75%
65 mesh 14.69%
100 mesh 8.58%
150 mesh 4.26%
Passed 150 mesh 47.95%
Plasticity ..... Medium
Molding properties ..... Fair
Drying properties ..... Good
Linear drying shrinkage 8.79%
Tempering water 28.40%
Oxidation ..... Difficult, 56% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 08
Heat range ..... Cone 010 to cone 08; bloats above cone 08; at cone 04 the trials are larger than before burning; cracks in burning.
When burned at cone 08—
Burning shrinkage 7.07%
Total shrinkage 15.86%
Porosity 3.02%
Fracture ..... Stony
Color ..... Light red, scums slightly.
Possibilities ..... A very unsuitable material as it is difficult to oxidize, cracks in burning, and is sensitive to overfiring and bloating.

WABASH COAL COMPANY, MINE NO. 2, ATHENS

(See figure 39)

Coal bed—No. 5.

Sample 9.—Location in mine, 3,000 feet from shaft; sample represents floor material; hard, gray, slightly calcareous shale, full of small concretions of calcium carbonate and partly decomposed pyrite.

Slaking test	Slakes in 1 hour.
Residues left on screens—	
10 mesh	16.00%
20 mesh	1.90%
60 mesh	9.10%
100 mesh	1.40%
120 mesh	0.10%
Passed 120 mesh	71.50%
Plasticity	Good
Molding properties	Good
Drying properties	Warps
Linear drying shrinkage	10.95%
Volume drying shrinkage	36.38%
Tempering water	30.66%
Oxidation	No tests made.
Maximum safe burning temperature	Cone 02
Heat range	Cone 06 to cone 02; cracks in burning; surface pits due to hydration and swelling of lime granules; bloats above cone 02.
When burned at cone 02—	
Burning shrinkage	5.16%
Total shrinkage	16.11%
Porosity	21.55%
Fracture	Vitreous
Color	Dark red to greenish brown.
Possibilities	An unsafe material, as it warps in drying, cracks in burning, and pits.

Sample 38.—Represents floor material of coal; sample as sent by company had been wet and had slaked to a soft, earthy, granular mass; contains granules of calcium carbonate, pyrite, and carbonaceous matter.

Slaking test	Slakes readily.
Residues left on screens—	
10 mesh	1.20%
20 mesh	8.23%
35 mesh	24.40%
65 mesh	15.83%
100 mesh	6.73%
150 mesh	3.79%
Passed 150 mesh	39.87%
Plasticity	Good
Molding properties	Good
Drying properties	Cracks
Linear drying shrinkage	8.11%
Tempering water	24.30%
Oxidation	Difficult, 57% oxidized in 14 hours.

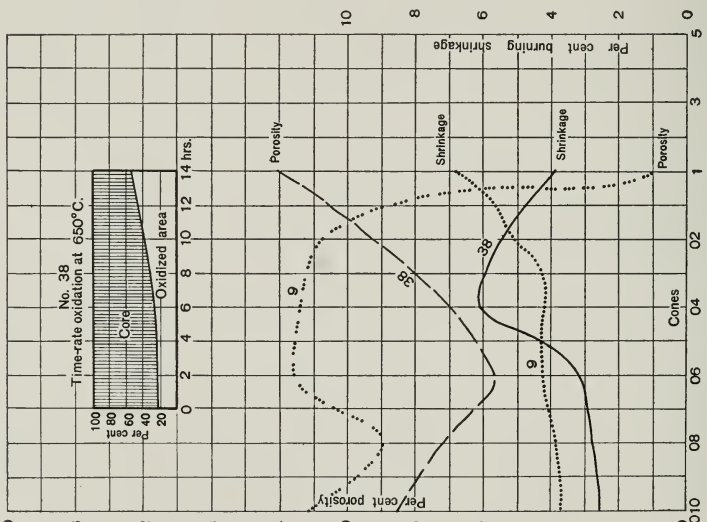


FIG. 39.—Graphic illustration of the laboratory tests of Samples 9 and 38, floor materials in mine No. 2, Wabash Coal Company, Athens.

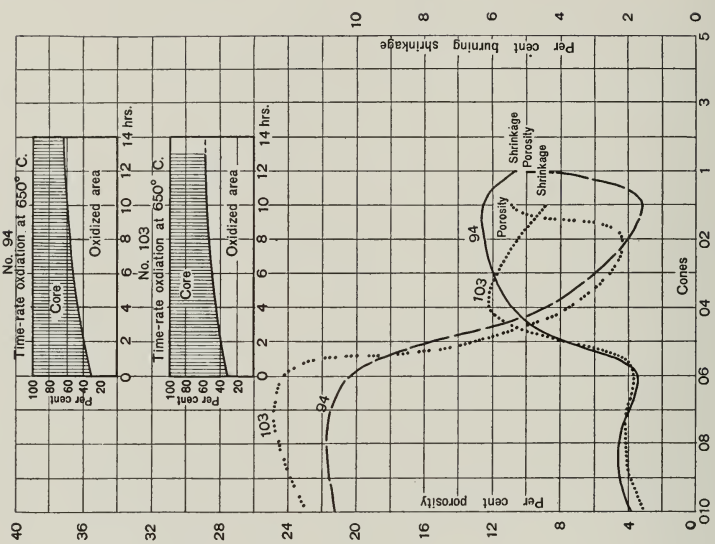


FIG. 40.—Graphic illustration of the laboratory tests of Samples 94 and 103, floor materials in mine No. 2, Clark Coal & Coke Company, Peoria.

Maximum safe burning temperature ..... Cone 06
Heat range ..... Short; bloating occurs above cone 06; cracks in burning.
When burned at cone 06—
Burning shrinkage 3.03%
Total shrinkage 11.19%
Porosity 11.64%
Fracture ..... Stony
Color ..... Dull red
Possibilities ..... Of no practical value; a very unsuitable material as it cracks in drying, is difficult to oxidize, cracks and bloats in burning, and has short heat range.

CLARK, COAL & COKE COMPANY, MINE NO. 2, PEORIA

(See figure 40)

Depth of shaft—186 feet.
Coal bed—No. 5.

Sample 94.—Location in mine, 17th W. off main S; sample represents floor material from 0 to 24 inches below coal; a mixture of light-gray shale banded with dark gray, decidedly calcareous and a blue-gray material resembling fire clay in structure and slightly calcareous; contains pyrite concretions and carbonaceous material as plant fossils.

Slaking test ..... Imperfectly slaked at end of test.
Residues left on screens—
10 mesh 48.18%
20 mesh 12.62%
35 mesh 10.16%
65 mesh 11.00%
100 mesh 4.05%
150 mesh 2.04%
Passed 150 mesh 11.95%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 7.60%
Volume drying shrinkage 24.20%
Tempering water 22.40%
Oxidation ..... Difficult, 64% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 01
Heat range ..... Cone 04 to cone 01; cracks in burning; bloats above cone 01.
When burned at cone 01—
Burning shrinkage 6.34%
Total shrinkage 13.94%
Porosity 3.06%
Fracture ..... Dense, stony
Color ..... Red at cone 04, dark brown at cone 01.
Possibilities ..... Not a safe raw material, as it is difficult to oxidize, cracks in burning, and is sensitive to bloating.

Sample 103.—Location in mine, 15th E. off main S.; sample represents floor material from 0 to 27 inches below coal to bedding plane called the "smooth parting"; medium hard, very dark gray calcareous shale banded with light gray; contains pyrite concretions, hard clay-like concretions high in calcium carbonate, and some carbonaceous matter as plant fossils.

Section of material sampled—
1. Clay, very soft ..... 1 inch
2. Clay, gray hard ..... 8 inches
3. Clay, darker ..... 10 inches
4. Clay, gray, hard ..... 8 inches

Slaking test ..... Imperfectly slaked at end of test.

Residues left on screens—
10 mesh 27.43%
20 mesh 14.98%
35 mesh 15.68%
65 mesh 13.54%
100 mesh 6.25%
150 mesh 1.76%
Passed 150 mesh 20.36%

Plasticity ..... Good

Molding properties ..... Good

Drying properties ..... Warps
Linear drying shrinkage 7.19%
Tempering water 3.70%

Oxidation ..... Difficult to oxidize in 13 hours.

Maximum safe burning temperature ..... Cone 04

Heat range ..... Short; cracks in burning; bloats above cone 04.

When burned at cone 04—
Burning shrinkage 6.02%
Total shrinkage 13.21%
Porosity 7.74%
Fracture ..... Stony
Color ..... Dull dark red; scums.

Possibilities ..... A very unsuitable material as it warps in drying, is difficult to oxidize, cracks in burning, has short heat range, and is sensitive to overfiring.

CRESCENT COAL COMPANY, MINE NO. 1, PEORIA

(See figure 41)

Depth of shaft—185 feet.

Coal bed—No. 5.

Sample 65.—Location in mine, 3,200 feet W. on main entry; sample represents floor material from 0 to 24 inches below coal; dark, slate-gray, calcareous shale; contains carbonaceous matter in thin seams as plant fossils and shows traces of calcium sulphate.

Slaking test ..... Imperfectly slaked at end of test.

Residues left on screens—

10 mesh	53.78%
20 mesh	12.90%
35 mesh	10.85%
65 mesh	7.01%
100 mesh	3.15%
150 mesh	1.94%
Passed 150 mesh	10.37%

Plasticity ..... Fair

Molding properties ..... Good

Drying properties ..... Warps and cracks

Linear drying shrinkage	7.36%
Volume drying shrinkage	23.55%
Tempering water	24.10%

Oxidation ..... Difficult, 68% oxidized in 14 hours.

Maximum safe burning temperature ..... Cone 08

Heat range ..... Very short; cracks in burning.

When burned at cone 08—

Burning shrinkage	0.09%
Total shrinkage	7.45%
Porosity	31.02%
Fracture	Stony
Color	Pale red; scums excessively.

Possibilities ..... Worthless as a raw material for manufacturing clay products, as it warps and cracks in drying, is difficult to oxidize, cracks in burning, and scums excessively.

Sample 83.—Location in mine, 3,700 feet W. of shaft; sample represents floor material from 0 to 23 inches below coal; medium hard, slate-gray shale, somewhat calcareous; contains streaks of carbonaceous matter.

Slaking test ..... Incompletely slaked at end of test.

Residues left on screens—

10 mesh	56.62%
20 mesh	10.85%
35 mesh	11.61%
65 mesh	8.50%
100 mesh	2.96%
150 mesh	1.46%
Passed 150 mesh	8.00%

Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Cracks
Linear drying shrinkage 6.48%
Tempering water 20.10%
Oxidation .....Difficult, 62% oxidized in 13 hours.
Maximum safe burning temperature .....Cone 01

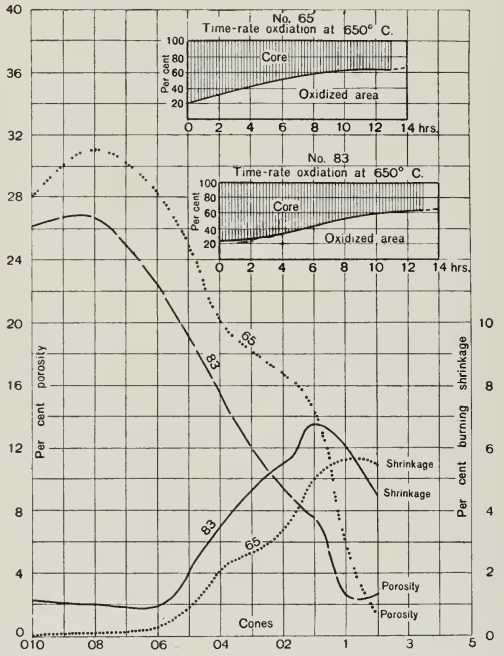


Fig. 41.—Graphic illustration of the laboratory tests of Samples 65 and 83, floor materials in mine No. 1, Crescent Coal Company, Peoria.

Heat range ....Cone 02 to cone 01; cracks in burning.
When burned at cone 01—
Burning shrinkage 6.72%
Total shrinkage 13.20%
Porosity 7.53%
Fracture .....Dense, stony
Color .....Dark brown; scums.
Possibilities .....A very unsuitable material, as it cracks in drying, is difficult to oxidize, cracks in burning, and has short heat range.

COLLIERS COOPERATIVE COAL COMPANY, MINE NO. 1, SOUTH BARTONVILLE

(See figure 42)

Depth of shaft—130 feet.

Coal bed—No. 5.

Sample 90.—Location in mine, 1st N. off main W.; sample represents floor material from 0 to 25 inches below coal; dark, slate-gray shale, banded with light-gray, medium hard, calcareous shale; contains pyrite concretions and carbonaceous matter in streaks.

Slaking test	Imperfectly slaked at end of test.
Residues left on screens—	
10 mesh	65.00%
20 mesh	9.45%
35 mesh	7.42%
65 mesh	6.76%
100 mesh	2.29%
150 mesh	1.45%
Passed 150 mesh	7.63%
Plasticity	Fair
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	7.12%
Tempering water	24.10%
Oxidation	Difficult, 76% oxidized in 14 hours.
Maximum safe burning temperature	Cone 01
Heat range	Short; cracks in burning; bloats above cone 01.
When burned at cone 01—	
Burning shrinkage	6.97%
Total shrinkage	14.09%
Porosity	0.98%
Fracture	Dense, stony
Color	Pale red at cone 010 to brown at cone 02.
Possibilities	A very unsuitable raw material, as it is difficult to oxidize, has short heat range, cracks in burning, and is sensitive to bloating.

Sample 91.—Location in mine, same as Sample 90; sample represents from 25 to 47 inches of floor material; medium hard, dark, slate-gray shale similar to the previous sample in appearance, mixed with hard, light-gray shale mottled with dark gray and brown; both shales are calcareous, the light-gray shale containing much more calcium carbonate than the dark.

Slaking test	Slakes imperfectly.
Residues left on screens—	
10 mesh	69.80%
20 mesh	15.20%
35 mesh	6.25%
65 mesh	3.29%
100 mesh	1.33%
150 mesh	0.69%
Passed 150 mesh	3.65%
Plasticity	Fair
Molding properties	Good
Drying properties	Warps
Linear drying shrinkage	5.20%
Tempering water	17.90%

Oxidation .....Difficult, 95% oxidized in 14 hours.
Maximum safe burning temperature .....Above cone 5
Heat range .....Temperature not carried high enough to determine this; cracks excessively in burning.

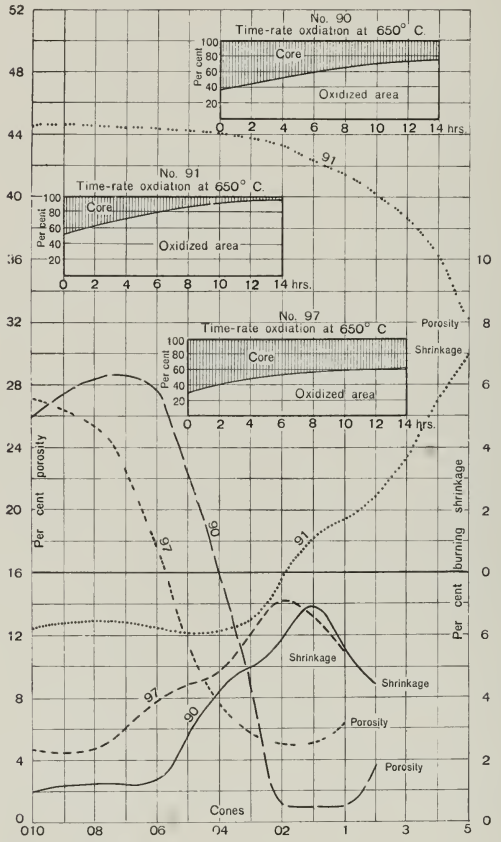


FIG. 42.—Graphic illustration of the laboratory tests of Samples 90, 91, and 97, floor materials in mine No. 1, Colliers Cooperative Coal Company, South Bartonville.

When burned at cone 5—
Burning shrinkage 7.00%
Total shrinkage 12.20%
Porosity 32.18%
Fracture ..... Stony
Color .....Mottled light and dark buff.
Possibilities .....Unsafe as it warps in drying, is difficult to oxidize, and cracks in burning.

Sample 97.—Location in mine, 600 yards from shaft on main W. entry; sample represents from 0 to 22 inches of floor material below coal; light and dark slate-gray lumps; structure resembles fire clay; shows occasional slickensides; contains considerable calcareous matter and much carbonaceous matter as plant fossils, both being finely distributed in streaks.

Slaking test.....Imperfectly slaked at end of test.
Residues left on screens—
10 mesh 31.40%
20 mesh 11.78%
35 mesh 11.36%
65 mesh 11.62%
100 mesh 3.20%
150 mesh 3.02%
Passed 150 mesh 27.62%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 7.11%
Volume drying shrinkage 22.80%
Tempering water 22.40%
Oxidation .....Difficult, 61% oxidized in 14 hours.
Maximum safe burning temperature .....Cone 02
Heat range .....Cone 04 to cone 02; cracks in burning; bloats above cone 02.
When burned at cone 02—
Burning shrinkage 7.11%
Total shrinkage 14.22%
Porosity 5.00%
Fracture .....Dense, stony
Color .....Dark red.
Possibilities .....A very unsuitable material, as it is difficult to oxidize and cracks in burning.

CANTRALL COOPERATIVE COAL COMPANY, CANTRALL MINE, CANTRALL

(See figure 43)

Coal bed—No. 5.

Sample 10.—Location in mine, room south; sample represents 4 feet of roof material; hard, very dark-brown shale that breaks into thin plates; contains pyrite particles and carbonaceous matter in thin coal seams.

Slaking test .....Slakes slowly.
Residues left on screens—
10 mesh 7.70%
20 mesh 12.50%
60 mesh 11.50%
100 mesh 3.00%
120 mesh 1.70%
Passed 120 mesh 63.60%
Plasticity .....Rather low.
Molding properties .....Molds with difficulty.
Drying properties ..... Good
Linear drying shrinkage 7.67%
Volume drying shrinkage 25.40%
Tempering water 27.45%
Oxidation .....Difficult, 72% oxidized in 8 hours.
Maximum safe burning temperature .....Cone 03
Heat range .....Very short; bloats above cone 03.

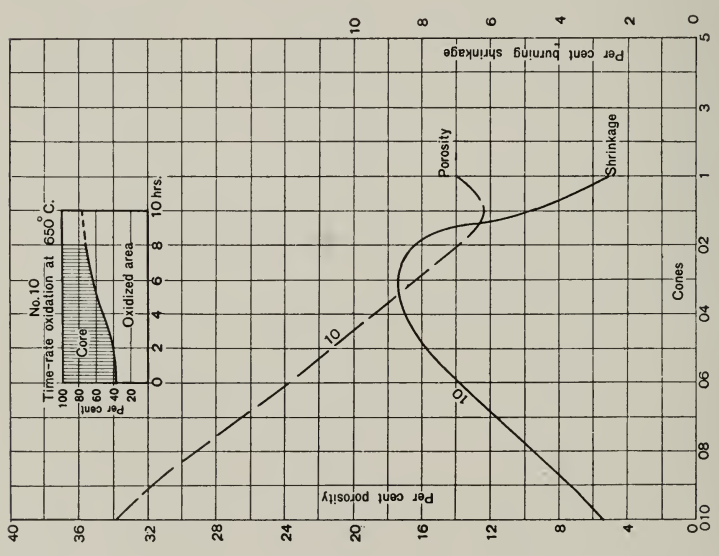


FIG. 43.—Graphic illustration of the laboratory tests of Sample 10, roof material in Cantrall mine, Cantrall Cooperative Coal Company, Cantrall.

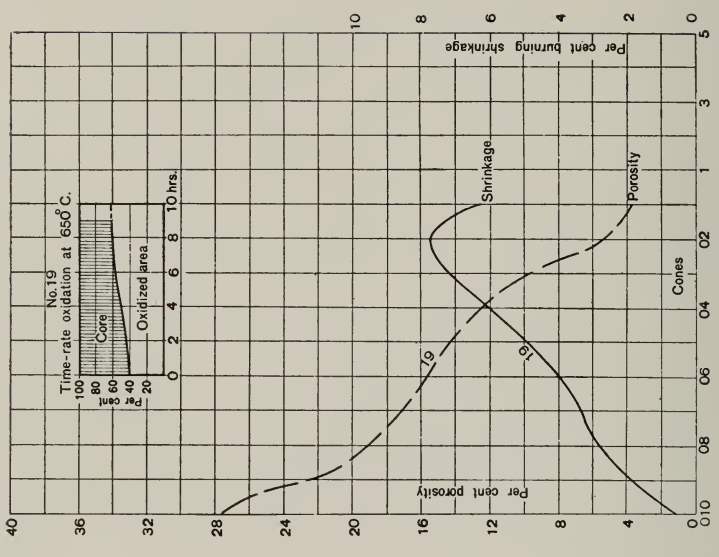


FIG. 44.—Graphic illustration of the laboratory tests of Sample 19, floor material in mine of Williamsville Coal Company, Selbytown.

When burned at cone 03—
- Burning shrinkage 8.75%
- Total shrinkage 16.42%
- Porosity 16.16%
- Fracture ..... Coarse, stony
- Color ..... Bright cherry red

Possibilities ..... Not a safe material as it is difficult to mold, difficult to oxidize, has short heat range, and is sensitive to overfiring.

WILLIAMSVILLE COAL COMPANY, SELBYTOWN

(See figure 44)

Coal bed—No. 5.

Thickness of floor clay—Averages 3 feet.

Sample 19.—Represents 24 inches of floor material; medium soft, gray shale streaked with buff; contains carbonaceous matter and granules of calcium carbonate.

Slaking test ..... Slakes in 1 hour.

Residues left on screens—
- 10 mesh 0.10%
- 20 mesh 0.10%
- 60 mesh 4.70%
- 100 mesh 0.10%
- 120 mesh 0.10%
- Passed 120 mesh 94.90%

Plasticity ..... Fair

Molding properties ..... Good

Drying properties ..... Warps and cracks; high-drying shrinkage.
- Linear drying shrinkage 13.18%
- Tempering water 33.18%

Oxidation ..... Difficult, 62% oxidized in 9 hours.

Maximum safe burning temperature ..... Cone 02

Heat range ..... Very short; cracks in burning; bloats above cone 02.

When burned at cone 02—
- Burning shrinkage 7.69%
- Total shrinkage 20.87%
- Porosity 5.30%
- Fracture ..... Stony
- Color ..... Dark red; scums

Possibilities ..... Unsafe for manufacture of clay products as it warps and cracks in drying, is difficult to oxidize, has short heat range, cracks in burning, and is sensitive to overfiring.

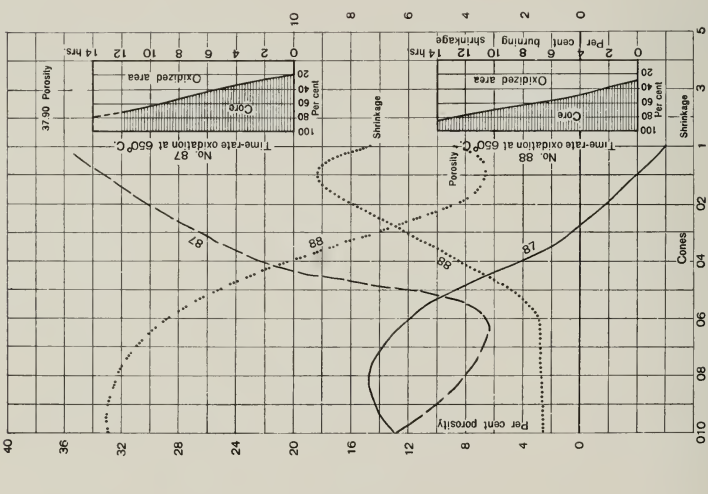


FIG. 45.—Graphic illustration of the laboratory tests of Samples 87 and 88, floor materials in the mine of Illinois Midland Coal Company, Sherman.

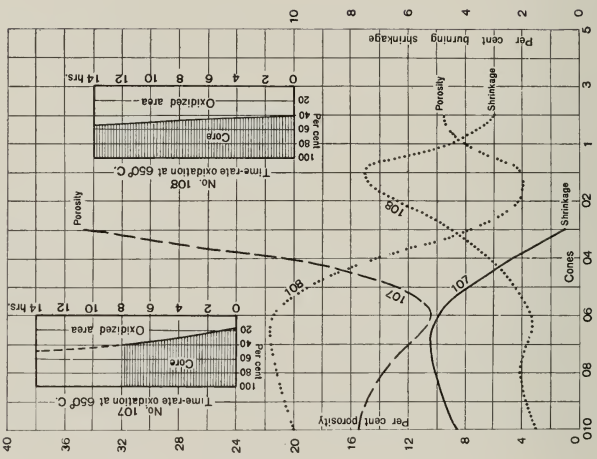


FIG. 46.—Graphic illustration of the laboratory tests of Samples 107 and 108, floor materials in the mine of Illinois Midland Coal Company, Sherman.

ILLINOIS MIDLAND COAL COMPANY, SHERMAN

(See figures 45 and 46)

Depth of shaft—221 feet.

Coal bed—No. 5.

Sample 87.—Location in mine, 3d N. off main W. 200 feet from shaft; sample represents floor clay from 7 to 17 inches below coal; gray-green, calcareous, partly weathered (or slaked) clay; contains carbonaceous matter and altered pyrite.

Slaking test	Practically complete at end of test.
Residues left on screens—	
10 mesh	15.30%
20 mesh	29.32%
35 mesh	18.50%
65 mesh	12.40%
100 mesh	5.34%
150 mesh	2.92%
Passed 150 mesh	16.22%
Plasticity	Fair
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	7.01%
Tempering water	24.00%
Oxidation	Difficult, 72% oxidized in 12 hours.
Maximum safe burning temperature	Cone 08
Heat range	Cone 010 to cone 08; bloats above cone 08.
When burned at cone 08—	
Burning shrinkage	7.32%
Total shrinkage	14.33%
Porosity	7.94%
Fracture	Stony
Color	Light red
Possibilities	Doubtful as it is difficult to oxidize, has short heat range, and is sensitive to overfiring.

Sample 88.—Location of mine, same as Sample 87; sample represents floor material from 17 to 35 inches below coal; similar characteristics to Sample 87, but contains considerably more finely distributed calcium carbonate.

Slaking test	Imperfectly slaked at end of test.
Residues left on screens—	
10 mesh	12.81%
20 mesh	32.49%
35 mesh	32.04%
65 mesh	9.93%
100 mesh	3.25%
150 mesh	1.73%
Passed 150 mesh	7.75%
Plasticity	Good
Molding properties	Good
Drying properties	Cracks
Linear drying shrinkage	6.31%
Tempering water	22.00%
Oxidation	Difficult, 84% oxidized in 14 hours.

Maximum safe burning temperature ..... Cone 01
Heat range ..... Short; cracks in burning; bloats above cone 01.
When burned at cone 01—
Burning shrinkage 9.26%
Total shrinkage 15.57%
Porosity 6.61%
Fracture ..... Stony
Color ..... Pale red at cone 08 to brown at cone 01.
Possibilities ..... Not a suitable raw material as it cracks in drying, is difficult to oxidize, has short heat range, and cracks in burning.

Sample 107.—Location in mine, 3d off 10 N.; sample represents floor material from 5 to 20 inches below coal; medium hard, calcareous, dark-gray shale; contains small pyrite concretions and carbonaceous matter in the form of plant fossils.

Slaking test ..... Slakes in 13 hours.
Residues left on screens—
10 mesh 0.80%
20 mesh 4.45%
35 mesh 12.20%
65 mesh 20.05%
100 mesh 7.78%
150 mesh 4.53%
Passed 150 mesh 50.19%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 10.65%
Tempering water 31.30%
Oxidation ..... Difficult, 37% oxidized in 8 hours.
Maximum safe burning temperature ..... Cone 06
Heat range ..... Short; cracks in burning; bloats above cone 06.
When burned at cone 06—
Burning shrinkage 4.90%
Total shrinkage 15.55%
Porosity 10.39%
Fracture ..... Stony
Color ..... Dark red; scums slightly.
Possibilities ..... A very unsuitable material as it is difficult to oxidize, cracks in burning, and is sensitive to overfiring.

Sample 108.—Represents floor material from 20 to 30 inches below coal; very similar in appearance to Sample 107 though apparently higher in lime.

Slaking test ..... Slakes in 11 hours.
Residues left on screens—
10 mesh 0.89%
20 mesh 1.46%
35 mesh 9.13%
65 mesh 7.89%
100 mesh 6.70%
150 mesh 6.40%
Passed 150 mesh 67.53%
Plasticity ..... Good
Molding properties ..... Good

Drying properties ..... Good
Linear drying shrinkage 9.96%
Tempering water 30.00%
Oxidation ..... Difficult; 55% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 01
Heat range ..... Very short; cracks excessively in burning; bloats above cone 01.
When burned at cone 01—
Burning shrinkage 7.56%
Total shrinkage 17.52%
Porosity 4.05%
Fracture ..... Dense, stony.
Color ..... Light red at cone 04, brown at cone 01; scums.
Possibilities ..... Very unsuitable material, as it is difficult to oxidize, has short heat range, and cracks in burning.

MONTOUR COAL COMPANY, MINE NO. 400, SPRINGFIELD

(See figure 47)

Depth of shaft—230 feet.
Coal bed—No. 5.

Sample 68.—Location in mine, 5th N. off 12 W. off main N.; sample represents floor material from 3 to 25 inches below coal; medium hard, dark-gray to brown clay; structure resembles that of fire clay; shows occasional slickensides; contains finely distributed calcium carbonate, a few lime concretions, occasional streaks of pyrite, and is high in carbon.

Slaking test ..... Slakes in 7 days.
Residues left on screens—
10 mesh 6.17%
20 mesh 18.85%
35 mesh 16.04%
65 mesh 20.31%
100 mesh 5.96%
150 mesh 5.30%
Passed 150 mesh 27.37%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Cracks
Linear drying shrinkage 8.19%
Tempering water 26.10%
Oxidation ..... Difficult, 53% oxidized in 12 hours.
Maximum safe burning temperature ..... Cone 06
Heat range ..... Very short; cracks in burning; bloats above cone 06.
When burned at cone 06—
Burning shrinkage 4.72%
Total shrinkage 12.91%
Porosity 6.86%
Fracture ..... Stony
Color ..... Light red.
Possibilities ..... Of no value, as it cracks in drying, is difficult to oxidize, has short heat range, cracks in burning, and is sensitive to bloating.

Sample 102.—Location in mine, 11th W. off main N.; sample represents floor material from 8 to 45 inches below coal; hard, calcareous, dark greenish-gray clay; contains gypsum and carbonaceous matter as plant fossils.

Slaking test ..... Slakes imperfectly.
Residues left on screens—
10 mesh 29.14%
20 mesh 8.03%
35 mesh 12.94%
65 mesh 19.25%
100 mesh 3.20%
150 mesh 3.61%
Passed 150 mesh 23.83%
Plasticity ..... Good

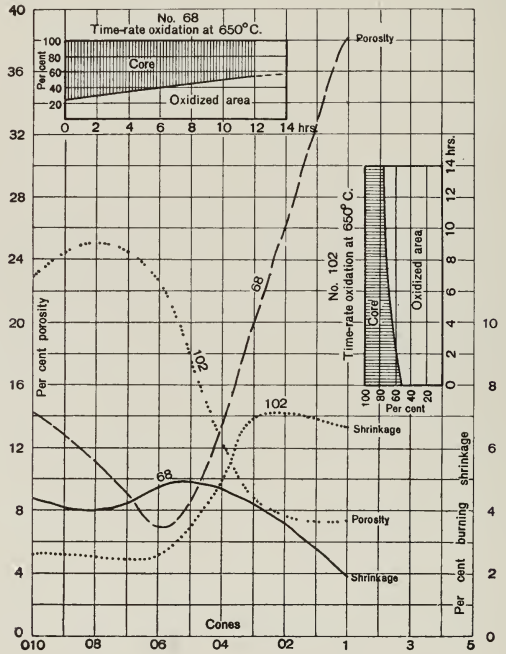


Fig. 47.—Graphic illustration of the laboratory tests of Samples 68 and 102, floor materials in mine No. 400, Montour Coal Company, Springfield.

Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 7.18%
Volume drying shrinkage 21.70%
Tempering water 25.70%
Oxidation ..... Difficult, 76% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 03
Heat range ..... Short; cracks excessively in burning; bloats above cone 03.

When burned at cone 03—
- Burning shrinkage 6.89%
- Total shrinkage 14.16%
- Porosity 8.81%
- Fracture ..... Stony
- Color ..... Light cherry red; scums.

Possibilities ..... A very unsuitable material, as it is difficult to oxidize, cracks in burning, and has short heat range.

SPRINGFIELD DISTRICT COAL MINING COMPANY, MINE NO. 5, SPRINGFIELD

(See figures 48 and 49)

Depth of shaft—250 feet.

Coal bed—No. 5.

Sample 99.—Location in mine, 1st W. off main S. 1,400 feet out; sample represents floor material from 0 to 17 inches below coal; medium hard, calcareous, dark, slate-gray clay; contains occasional fragments nearly black in color, showing slickensides and high in carbonaceous matter.

Slaking test ..... Imperfectly slaked at end of test.

Residues left on screens—
- 10 mesh 50.15%
- 20 mesh 21.10%
- 35 mesh 9.08%
- 65 mesh 6.04%
- 100 mesh 3.19%
- 150 mesh 2.00%
- Passed 150 mesh 8.44%

Plasticity ..... Fair

Molding properties ..... Good

Drying properties ..... Warps
- Linear drying shrinkage 6.49%
- Tempering water 22.60%

Oxidation ..... Difficult, 69% oxidized in 13 hours.

Maximum safe burning temperature ..... Cone 04.

Heat range ..... Very short; cracks in burning; bloats above cone 04.

When burned at cone 04—
- Burning shrinkage 7.31%
- Total shrinkage 13.80%
- Porosity 8.10%
- Fracture ..... Dense, stony.
- Color ..... Dull red; scums slightly.

Possibilities ..... A very unsuitable material as it warps in drying, is difficult to oxidize, has short heat range, and cracks in burning.

Sample 100.—Location in mine, same as Sample 99; sample represents floor material from 17 to 33 inches below coal; clay very similar in character to Sample 99 except dark-colored fragments are absent; contains carbonaceous matter as plant fossils.

Slaking test ..... Imperfectly slaked at end of test.

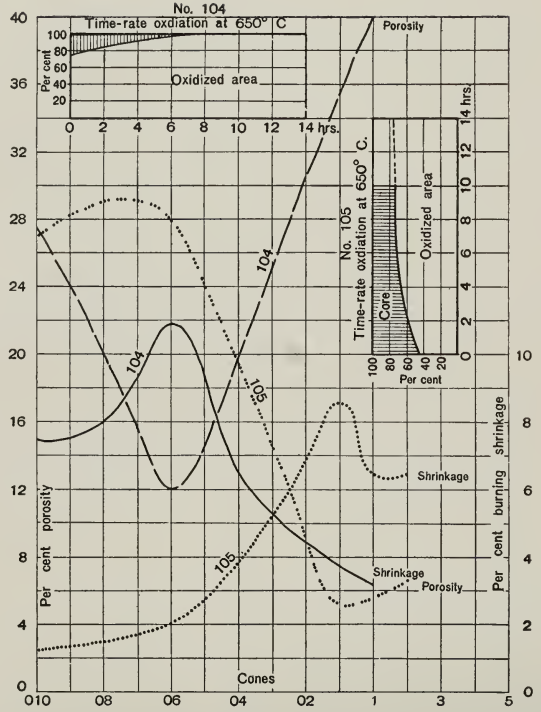


FIG. 48.—Graphic illustration of the laboratory tests of Samples 99 and 100, floor materials in mine No. 5, Springfield District Coal Mining Company, Springfield.

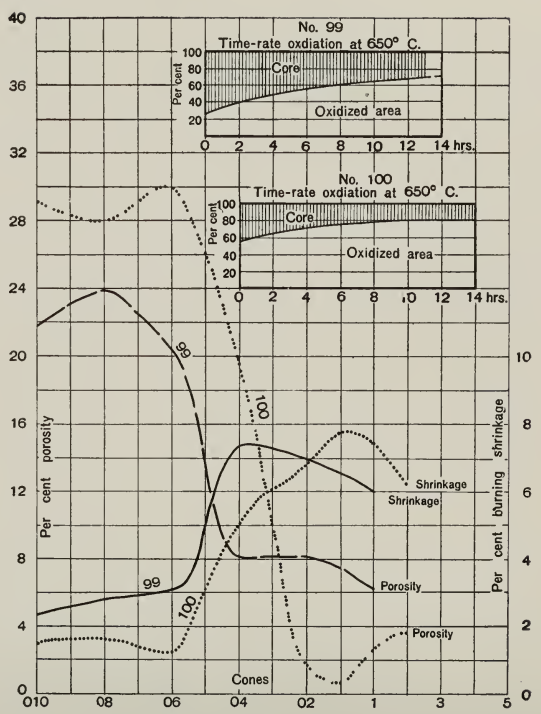


FIG. 49.—Graphic illustration of the laboratory tests of Samples 104 and 105, floor materials in mine No. 5, Springfield District Coal Mining Company, Springfield.

Residues left on screens—
- 10 mesh 54.20%
- 20 mesh 23.29%
- 35 mesh 8.74%
- 65 mesh 4.01%
- 100 mesh 1.65%
- 150 mesh 1.21%
- Passed 150 mesh 6.90%

Plasticity ..... Fair

Molding properties ..... Good

Drying properties ..... Good
- Linear drying shrinkage 6.71%
- Tempering water 22.10%

Oxidation ..... Difficult, 81% oxidized in 14 hours.

Maximum safe burning temperature ..... Cone 01

Heat range ..... Short; cracks in burning; bloats above cone 01.

When burned at cone 01—
- Burning shrinkage 7.75%
- Total shrinkage 14.46%
- Porosity 0.45%
- Fracture ..... Dense, stony.
- Color ..... Dull red at cone 03 to brown at cone 01; scums.

Possibilities ..... A very unsuitable material as it is difficult to oxidize, cracks in burning, and is sensitive to overfiring.

Sample 104.—Location in mine, motor room; sample represents floor material from 0 to 18 inches below coal; weathered (or partly slaked) calcareous clay, dark greenish-gray to black, streaked with yellow; contains carbonaceous matter, decomposed pyrite, gypsum, and sulphur.

Slaking test ..... Slaked in 13 hours.

Residues left on screens—
- 10 mesh 8.30%
- 20 mesh 2.20%
- 35 mesh 5.89%
- 65 mesh 6.10%
- 100 mesh 4.06%
- 150 mesh 2.40%
- Passed 150 mesh 71.05%

Plasticity ..... Good

Molding properties ..... Good

Drying properties ..... Warps and scums.
- Linear drying shrinkage 7.96%
- Tempering water 28.40%

Oxidation ..... Complete in 8 hours.

Maximum safe burning temperature ..... Cone 06

Heat range ..... Very short; cracks in burning; bloats above cone 06.

When burned at cone 06—
- Burning shrinkage 10.91%
- Total shrinkage 18.87%
- Porosity 11.99%
- Fracture ..... Stony
- Color ..... Medium red; scums.

Possibilities ..... Very unsuitable material as it warps in drying, has short heat range, and cracks in burning.

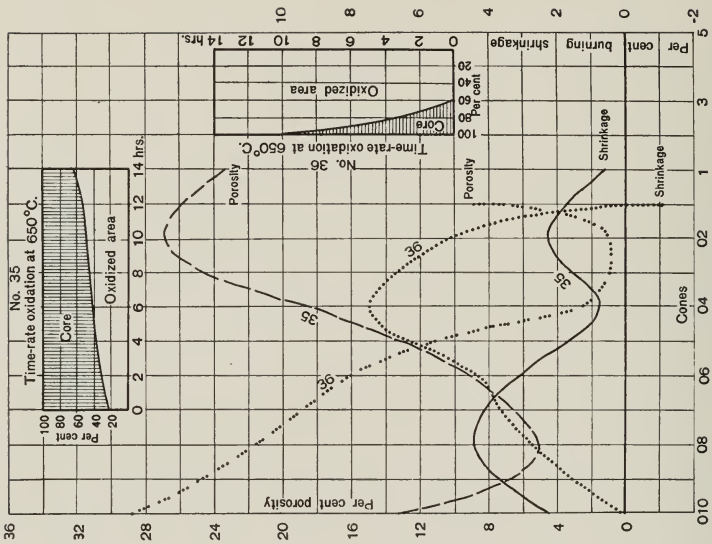


Fig. 51.—Graphic illustration of the laboratory tests of Sample 35, floor material, and Sample 36, roof material, in mine No. 1, W. P. Rend Collieries Company, Rend.

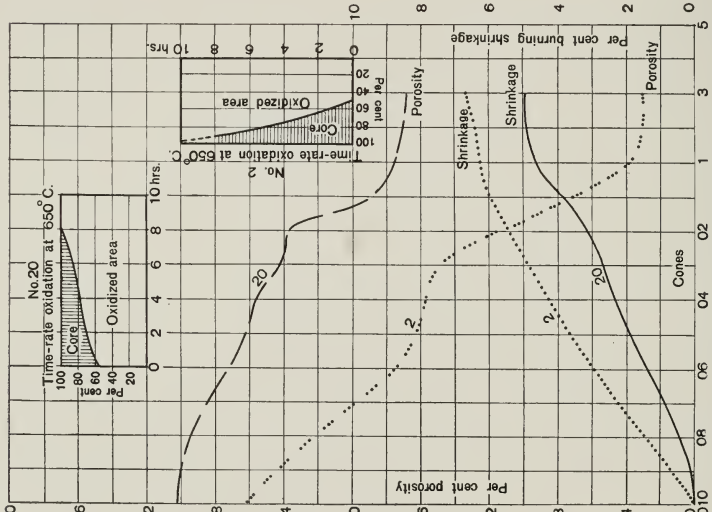


Fig. 50.—Graphic illustration of the laboratory tests of Sample 2, floor material, and Sample 20, roof material, in mine No. 2, Saline County Coal Company, Harrisburg.

Sample 105.—Location in mine, same as Sample 104; sample represents floor material from 18 to 42 inches below coal; partly weathered (or slaked), slate-gray, calcareous clay; contains decomposed pyrite, gypsum, and carbonaceous matter as plant fossils.

Slaking test.....Imperfectly slaked at end of test.
Residues left on screens—
10 mesh 6.48%
20 mesh 11.11%
35 mesh 26.00%
65 mesh 17.92%
100 mesh 6.22%
150 mesh 4.36%
Passed 150 mesh 27.91%
Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 8.89%
Tempering water 28.50%
Oxidation.....Difficult, 72% oxidized in 10 hours.
Maximum safe burning temperature.....Cone 01
Heat range.....Very short; cracks in burning; bloats above cone 01.
When burned at cone 01—
Burning shrinkage 8.51%
Total shrinkage 17.40%
Porosity 5.04%
Fracture .....Dense, stony.
Color .....Pale red; scums.
Possibilities .....A very unsuitable material as it is difficult to oxidize, cracks in burning, and has short heat range.

SALINE COUNTY COAL COMPANY, MINE NO. 2, HARRISBURG

(See figure 50)

Depth of shaft—96 feet.
Coal bed—No. 5.

Sample 2.—Location in mine, 8 E. main S.; sample represents floor material from 1 to 20 inches below coal; in structure clay resembles that of fire clay; shows well-developed slickensides; contains carbonaceous matter as plant fossils, streaks of pyrite, and occasional lime-iron carbonate concretions.

Slaking test .....Slakes rapidly.
Residues left on screens—
10 mesh 51.00%
20 mesh 25.90%
60 mesh 13.00%
100 mesh 2.00%
120 mesh 1.00%
Passed 120 mesh 7.10%
Plasticity .....Medium
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 4.44%
Volume drying shrinkage 13.95%
Tempering water 17.10%
Oxidation .....Difficult, 92% oxidized in 8 hours.
Maximum safe burning temperature..... Cone 3

Heat range.....Good, cone 1 to possibly cone 5 or 6.
When burned at cone 3—
Burning shrinkage 6.74%
Total shrinkage 11.18%
Porosity 3.16%
Fracture .....Vitreous
Color .....From light salmon at cone 010 to light red at cone 01 to light brown at cone 3; scums slightly.
Possibilities .....Common and front brick, hollow ware (hollow blocks, fireproofing, drain-tile, etc.).
Precautions.....Care must be taken in burning during oxidation.

Sample 20.—Location in mine, 8 E. main S.; sample represents roof material from 0 to 20 inches above coal; hard, slate-gray shale; contains numerous flakes of mica and dark streaks high in carbonaceous matter.

Slaking test .....No apparent action takes place.
Residues left on screen.....Practically all left on 10-mesh screen.
Plasticity ..... Low
Molding properties.....Somewhat troublesome in molding.
Drying properties ..... Good
Linear drying shrinkage 2.25%
Tempering water 14.11%
Oxidation .....Complete in 8 hours.
Maximum safe burning temperature.....Above cone 3
Heat range .....Cone 01 to above cone 3.
When burned at cone 3—
Burning shrinkage 4.98%
Total shrinkage 7.23%
Porosity 16.88%
Fracture .....Coarse, stony.
Color .....Dark red; very slight scumming.
Possibilities .....Common and front brick.
Precautions .....Would require thorough tempering or the addition of a suitable plastic clay to improve its molding properties.

W. P. REND COLLIERIES COMPANY, MINE NO. 1, REND

(See figure 51)

Depth of shaft—571 feet.
Coal bed—No. 6.

Sample 35.—Location in mine, face center course E. main ½ mile from shaft; sample represents floor material from 0 to 30 inches below coal; dark gray, medium hard clay with structure resembling that of fire clay; irregular fracture; contains granules of altered pyrite, carbonaceous matter in streaks, and lime-iron concretions.

Slaking test .....Action rather slow and incomplete.
Residues left on screens—
10 mesh 4.94%
20 mesh 28.60%
35 mesh 18.68%
65 mesh 14.50%
100 mesh 6.99%
150 mesh 3.87%
Passed 150 mesh 22.42%

Plasticity ..... Fair
Molding properties ..... Molds with some difficulty.
Drying properties ..... Good
Linear drying shrinkage 7.53%
Volume drying shrinkage 25.30%
Tempering water 18.90%
Oxidation ..... Difficult, 66% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 08.
Heat range ..... Very short; bloats above cone 08; cracks very badly in burning; pits occur due to lime-iron granules.
When burned at cone 08—
Burning shrinkage 4.42%
Total shrinkage 11.95%
Porosity 5.02%
Fracture ..... Stony
Color ..... Dull light red; scums slightly.
Possibilities ..... Not a practical working clay as it is difficult to mold and to oxidize, cracks in burning, pits, and is sensitive to bloating.

Sample 36.—Location in mine, main W. 200 feet from shaft; sample represents roof material from 0 to 36 inches above coal; hard, blue-gray shale that breaks up into flat concretionary form; contains pyrite concretions and granules of lime-iron carbonate, comparatively free from carbon.

Slaking test ..... Very little affected at end of test.
Residues left on screens—
10 mesh 80.78%
20 mesh 7.60%
35 mesh 4.03%
65 mesh 2.00%
100 mesh 0.69%
150 mesh 0.29%
Passed 150 mesh 4.61%
Plasticity ..... Rather low.
Molding properties ..... Molds with some difficulty.
Drying properties ..... Good
Linear drying shrinkage 3.36%
Volume drying shrinkage 10.94%
Tempering water 16.50%
Oxidation ..... Complete in 10 hours.
Maximum safe burning temperature ..... Cone 04
Heat range ..... Very short; bloats above cone 04; occasional surface pits due to lime-iron granules.
When burned at cone 04—
Burning shrinkage 7.55%
Total shrinkage 10.91%
Porosity 2.52%
Fracture ..... Dense, stony.
Color ..... Dull dark red.
Possibilities ..... Common brick; not suitable for hollow blocks because of molding difficulties.
Precautions ..... Would require thorough tempering.

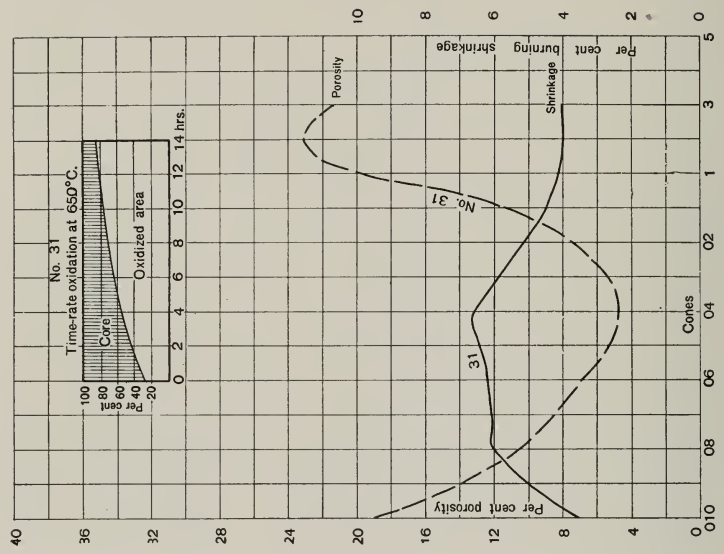


FIG. 53.—Graphic illustration of the laboratory tests of Sample 31, floor material in Jeffrey mine, Carterville & Herrin Coal Company, Herrin.

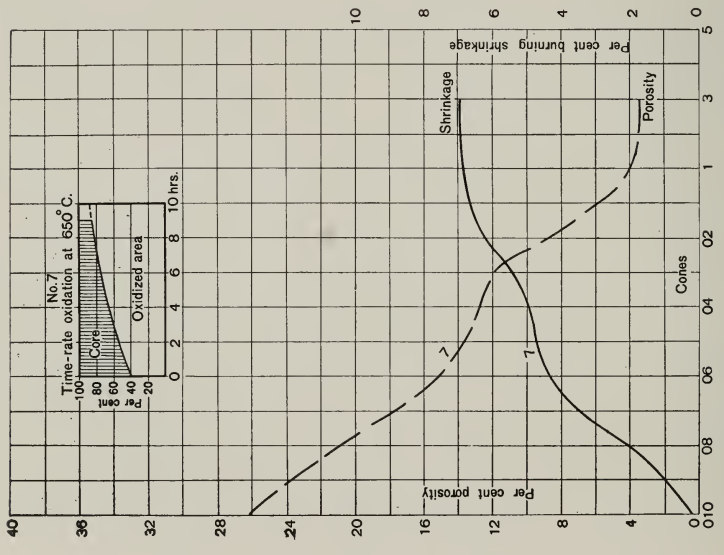


FIG. 52.—Graphic illustration of the laboratory tests of Sample 7, floor material in Sesser mine, Sesser Coal Company, Sesser.

SESSER COAL COMPANY, SESSER MINE, SESSER

(See figure 52)

Depth of shaft—647 feet.

Coal bed—No. 6.

Sample 7.—Represents floor material below coal; medium hard gray clay with structure resembling that of fire clay; shows slickensides; contains carbonaceous matter as plant fossils and in thin seams, no concretions or pyrite are noticeable.

Slaking test	Slakes slowly.
Residues left on screens—	
10 mesh	3.60%
20 mesh	0.38%
60 mesh	0.29%
100 mesh	0.19%
120 mesh	0.00%
Passed 120 mesh	95.54%
Plasticity	Fair
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	5.60%
Tempering water	20.32%
Oxidation	Difficult, 84% oxidized in 9 hours.
Maximum safe burning temperature	Above cone 3
Heat range	Cone 1 to above cone 3.
When burned at cone 3—	
Burning shrinkage	6.94%
Total shrinkage	12.54%
Porosity	3.40%
Fracture	Stony
Color	Light salmon at cone 010, light red at cone 02, light brown at cone 1.
Possibilities	Common and front brick, hollow ware.
Precautions	Requires care during the oxidizing period of the burn.

CARTERVILLE & HERRIN COAL COMPANY, JEFFREY MINE, HERRIN

(See figure 53)

Depth of shaft—134 feet.

Coal bed—No. 6.

Sample 31.—Location in mine, 100 feet southwest of shaft; sample represents floor material below coal; calcareous clay with structure resembling that of fire clay; occasional slickensides; contains streaks of iron oxide and finely distributed carbon in spots.

Slaking test	Slakes in 147 hours.
Residues left on screens—	
10 mesh	5.95%
20 mesh	14.35%
35 mesh	18.46%
65 mesh	21.90%
100 mesh	9.99%
150 mesh	3.00%
Passed 150 mesh	26.35%

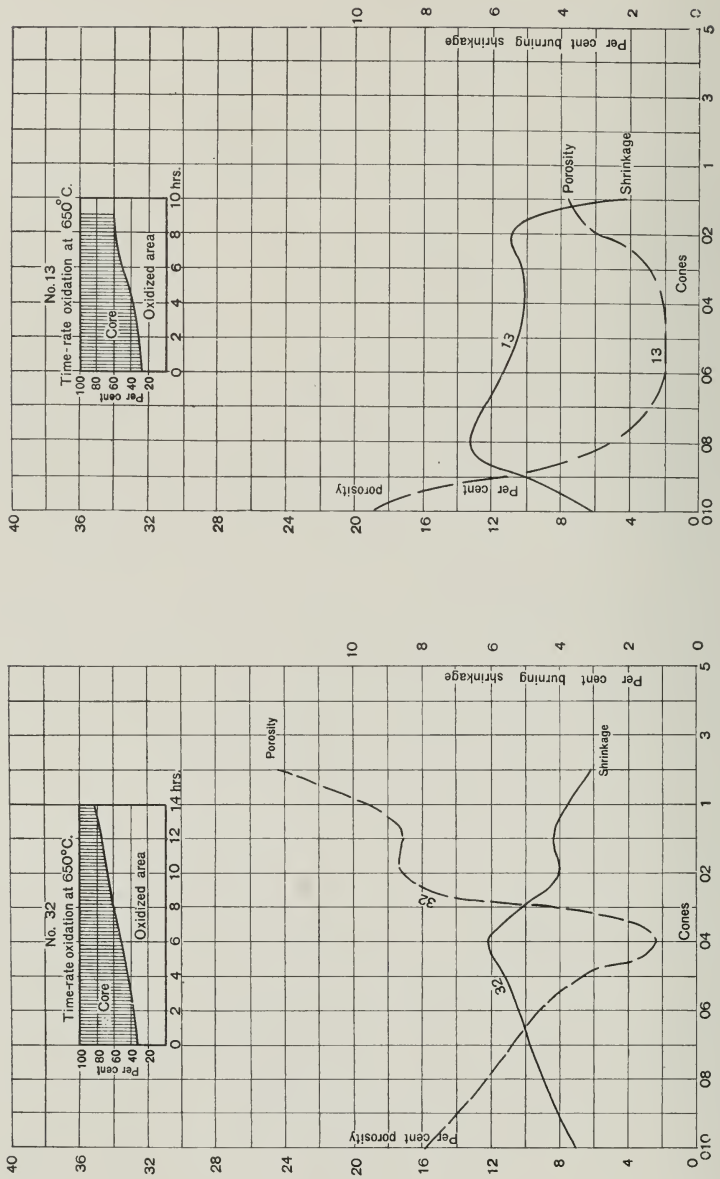


FIG. 54.—Graphic illustration of the laboratory tests of Sample 32, floor material in the stripping mine of Brinkley & Miles, Marion.

FIG. 55.—Graphic illustration of the laboratory tests of Sample 13, floor material in mine No. 1, Shoal Creek Coal Company, Panama.

Plasticity ..... Fair
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 7.33%
Volume drying shrinkage 21.40%
Tempering water 21.60%
Oxidation ..... Difficult, 84% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 04
Heat range ..... Cone 06 to cone 04; cracks in burning; bloats above cone 04.
When burned at cone 04—
Burning shrinkage 6.59%
Total shrinkage 13.92%
Porosity 4.59%
Fracture ..... Irregular, stony.
Color ..... Pale red to light green brown; scums.
Possibilities ..... Not suitable material as it is difficult to oxidize and cracks in burning.

BRINKLEY & MILES, MARION

(See figure 54)

Kind of mine—Stripping.
Coal bed—No. 6.

Sample 32.—Represents floor material from 1 to 18 inches below coal; medium hard, light-gray, calcareous shale, brown in spots and streaks; contains carbonaceous matter as plant fossils and concretions of calcium carbonate.

Slaking test ..... Slakes in 13 hours.
Residues left on screens—
10 mesh 3.89%
20 mesh 5.48%
35 mesh 6.17%
65 mesh 3.15%
100 mesh 1.19%
150 mesh 1.51%
Passed 150 mesh 78.61%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Cracks
Linear drying shrinkage 7.46%
Volume drying shrinkage 26.80%
Tempering water 21.30%
Oxidation ..... Difficult, 82% oxidized in 14 hours.
Heat range ..... Very short; cracks in burning; surface pits; bloats above cone 04.
When burned at cone 04—
Burning shrinkage 6.06%
Total shrinkage 13.52%
Porosity 2.31%
Fracture ..... Dense, stony.
Color ..... Light red to brown.
Possibilities ..... A very unsuitable material as it cracks in burning and in drying, is difficult to oxidize, has short heat range, and pits due to lime granules.

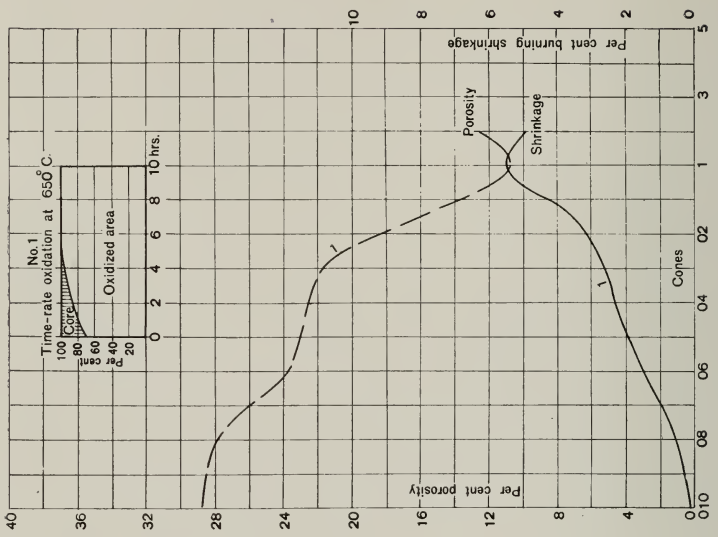


Fig. 57.—Graphic illustration of the laboratory tests of Sample 1, roof material in Paradise mine, Paradise Coal Company, Duquoin.

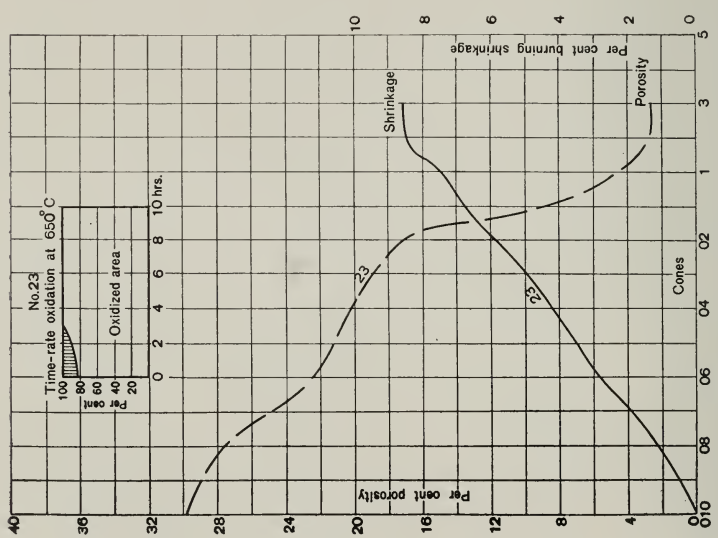


Fig. 56.—Graphic illustration of the laboratory tests of Sample 23, roof material in Horn mine, Brilliant Coal Company, Duquoin.

SHOAL CREEK COAL COMPANY, MINE NO. 1, PANAMA

(See figure 55)

Depth of shaft—374 feet.

Coal bed—No. 6.

Sample 13.—Represents floor material below coal; medium hard, calcareous, light-gray shale; contains small iron carbonate nodules, gypsum, and calcareous matter as plant fossils.

Slaking test ..... Slakes very slowly.

Residues left on screens—

10 mesh	6.90%
20 mesh	2.50%
60 mesh	3.80%
100 mesh	0.70%
120 mesh	0.00%
Passed 120 mesh	86.10%

Plasticity ..... Fair

Molding properties ..... Good

Drying properties ..... Warps, drying shrinkage high

Linear drying shrinkage	15.38%
Tempering water	37.95%

Oxidation ..... Difficult, 60% oxidized in 9 hours.

Maximum safe burning temperature ..... Cone 06

Heat range ..... Short; cracks in burning; bloats.

When burned at cone 06—

Burning shrinkage	5.69%
Total shrinkage	21.07%
Porosity	1.99%
Fracture	Stony
Color	Light red; scums excessively.

Possibilities ..... A very unsuitable material as it warps in drying, is difficult to oxidize, has short heat range; cracks in burning, is sensitive to overfiring, and scums excessively.

BRILLIANT COAL COMPANY, HORN MINE, DUQUOIN

(See figure 56)

Depth of shaft—75 feet.

Coal bed—No. 6.

Average thickness of roof—15 to 20 feet.

Sample 23.—Represents roof material above coal; hard, blue-gray shale easily separated into plates about ¼ inch thick; contains brown iron streaks, otherwise comparatively uniform in appearance.

No slaking and screening tests were made.

Plasticity ..... Fair

Drying properties ..... Good

Linear drying shrinkage	3.41%
Tempering water	18.48%

Oxidation ..... Complete in 3 hours.

Maximum safe burning temperature ..... Above cone 3.

Heat range ..... Cone 1 to above cone 3.

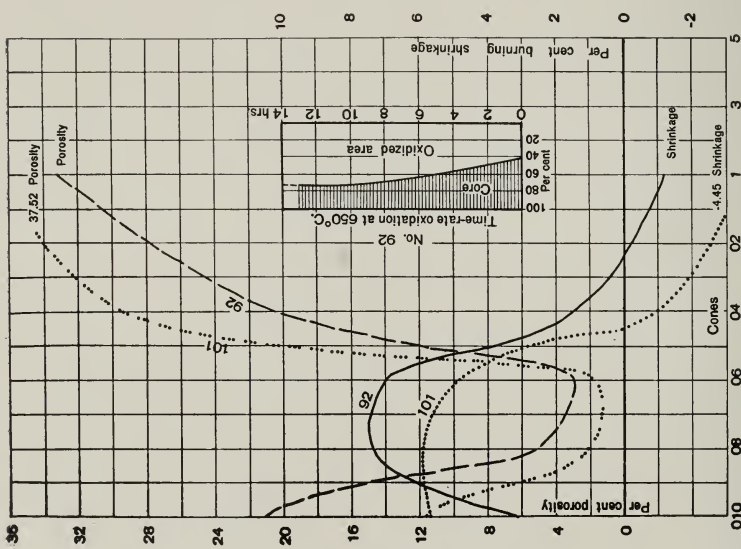


FIG. 58.—Graphic illustration of the laboratory tests of Samples 92 and 101, floor materials in mine of Pioneer Coal Company, Belleville.

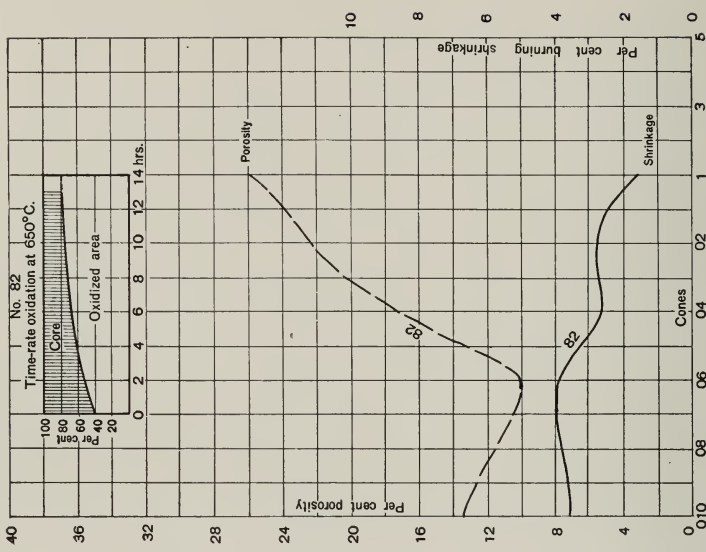


FIG. 59.—Graphic illustration of the laboratory tests of Sample 82, floor material in mine No. 2, Mulberry Hill Coal Company, Freeburg.

When burned at cone 3—
- Burning shrinkage 8.55%
- Total shrinkage 11.96%
- Porosity 2.69%
- Fracture ..... Smooth, dull.
- Color ..... Dark red; scums slightly.

Possibilities ..... Common, front, and paving brick, hollow ware.

PARADISE COAL COMPANY, PARADISE MINE, DUQUOIN

(See figure 57)

Depth of shaft—371 feet.

Coal bed—No. 6.

Sample 1.—Location of sample, room 1 NE.; sample represents roof material from 0 to 24 inches above coal; hard, dark-gray shale; contains a little calcium carbonate and occasional lime-iron carbonate concretions, comparatively free from carbon.

Slaking test ..... No shaking action noticeable.

Residues left on screens ... Practically all was left on 10-mesh screen.

Plasticity ..... Rather low.

Molding properties ..... Molds without serious difficulties.

Drying properties ..... Good
- Linear drying shrinkage 3.69%
- Volume drying shrinkage 11.22%
- Tempering water 16.10%

Oxidation ..... Complete in 5 hours.

Maximum safe burning temperature ..... Cone 1

Heat range ..... Short; bloats above cone 1.

When burned at cone 1—
- Burning shrinkage 5.50%
- Total shrinkage 9.19%
- Porosity 10.81%
- Fracture ..... Stony
- Color ..... Dull red; scums slightly.

Possibilities ..... Common and front brick.

Precautions ..... Should be thoroughly tempered to develop good molding plasticity.

PIONEER COAL COMPANY, BELLEVILLE

(See figure 58)

Depth of shaft—51 feet.

Thickness of floor clay—Variable.

Coal bed—No. 6.

Sample 92.—Location in mine, 3d E.; sample represents floor material from 0 to 16 inches below coal (taken down to pebble layer); a mixture of light-gray and blue-gray shale, partly weathered (or slaked); contains considerable carbonaceous matter, partly decomposed pyrite, and sulphur.

Slaking test ..... Slakes in 11 hours.

Residues left on screens—
- 10 mesh 0.06%
- 20 mesh 0.15%
- 35 mesh 1.32%
- 65 mesh 3.43%
- 100 mesh 3.11%
- 150 mesh 3.18%
- Passed 150 mesh 88.75%

Plasticity ..... Fair

Molding properties ..... Good

Drying properties ..... Good
- Linear drying shrinkage 9.54%
- Tempering water 21.20%

Oxidation .....Difficult, 70% oxidized in 13 hours.

Maximum safe burning temperature .....Cone 06

Heat range .....Cone 08 to cone 06; bloats above cone 06; cracks in burning.

When burned at cone 06—
- Burning shrinkage 6.93%
- Total shrinkage 16.47%
- Porosity 2.95%
- Fracture .....Vitreous
- Color .....Medium red.

Possibilities .....Not a suitable material as it is difficult to oxidize, cracks in burning, and is sensitive to overfiring and bloating.

Sample 101.—Locaton in mine, E. entry; sample represents floor material from 0 to 28 inches below coal (taken down to pebble layer); sample had been wet and partly slaked; contains considerable carcareous and carbonaceous matter and apparently decomposed pyrite, gives test for calcium sulphate.

Slaking test .....Slakes in 13 hours.

Residues left on screens—
- 10 mesh 0.46%
- 20 mesh 0.61%
- 35 mesh 1.65%
- 65 mesh 5.60%
- 100 mesh 4.24%
- 150 mesh 3.27%
- Passed 150 mesh 84.17%

Plasticity ..... Good

Molding properties ..... Good

Drying properties ..... Warps
- Linear drying shrinkage 11.37%
- Tempering water 31.60%

Oxidation .....No trials made.

Maximum safe burning temperature.....Cone 08

Heat range.....Short; very sensitive to overfiring and bloating.

When burned at cone 08—
- Burning shrinkage 5.88%
- Total shrinkage 17.25%
- Porosity 2.00%
- Fracture .....Dense, stony.
- Color .....Pale red; scums excessively.

Possibilities .....A very unsuitable material as it warps in drying, is sensitive to overfiring, and scums excessively.

MULBERRY HILL COAL COMPANY, MINE NO. 2, FREEBURG

(See figure 59)

Depth of shaft—150 feet.

Coal bed—No. 6.

Sample 82.—Location in mine, 100 feet out on main W.; sample represents floor material from 0 to 33 inches below coal; light-gray, medium soft, calcareous clay; contains small granules of calcium carbonate, streaks of carbonaceous matter, and calcium sulphate.

Slaking test	Slakes in 11 hours.
Residues left on screens—	
10 mesh	15.50%
20 mesh	0.90%
35 mesh	1.44%
65 mesh	1.48%
100 mesh	0.90%
150 mesh	0.70%
Passed 150 mesh	79.08%
Plasticity	Good
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	9.22%
Tempering water	28.80%
Oxidation	Difficult, 76% oxidized in 13 hours.
Heat range	Cone 08 to cone 06; cracks in burning; surface pits.
When burned at cone 06—	
Burning shrinkage	3.90%
Total shrinkage	13.12%
Porosity	10.24%
Fracture	Stony
Color	Pale red; scums excessively.
Possibilities	A very unsuitable material as it is difficult to oxidize, pits, cracks in burning, and scums excessively.

KOLB COAL COMPANY, MINE NO. 2, MASCOUTAH

(See figure 60)

Depth of shaft—168 feet.

Coal bed—No. 6.

Sample 85.—Location in mine, sump under air shaft; sample represents floor material from 0 to 24 inches below coal; gray-green, medium hard, calcareous clay; contains pyrite nodules, calcium carbonate concretions, and streaks of carbonaceous matter.

Slaking test	Slakes in 11 hours.
Residues left on screens—	
10 mesh	0.78%
20 mesh	0.57%
35 mesh	0.88%
65 mesh	1.20%
100 mesh	0.79%
150 mesh	0.64%
Passed 150 mesh	95.86%
Plasticity	Good
Molding properties	Good

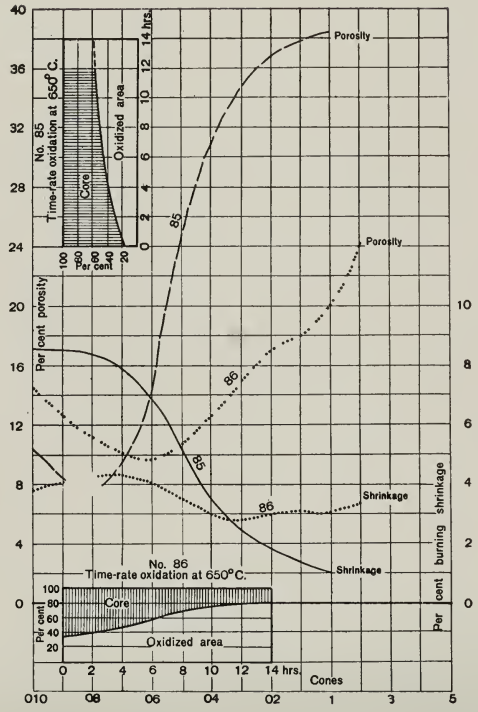


FIG. 60.—Graphic illustration of the laboratory tests of Samples 85 and 86, floor materials in mine No. 2, Kolb Coal Company, Mascoutah.

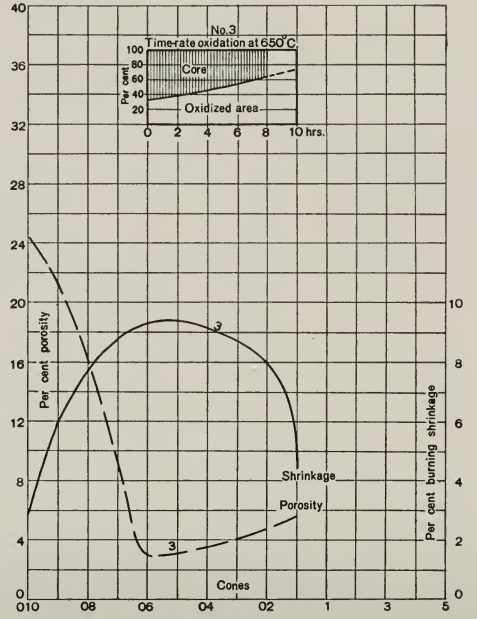


FIG. 61.—Graphic illustration of the laboratory tests of Sample 3, floor material in Taylor mine, Joseph Taylor Coal Company, O'Fallon.

Drying properties ..... Good
Linear drying shrinkage 10.20%
Tempering water 29.10%
Oxidation ..... Difficult, 53% oxidized in 12 hours.
Maximum safe burning temperature ..... Cone 08
Heat range ..... Cone 010 to cone 08; bloats above cone 08; surface pits are profuse.
When burned at cone 08—
Burning shrinkage 5.35%
Total shrinkage 15.55%
Porosity 1.79%
Fracture ..... Vitreous
Color ..... Light red; scums.
Possibilities ..... Not a suitable raw material as it is difficult to oxidize, has short heat range, is sensitive to overfiring, and pits.

Sample 86.—Location in mine, same as Sample 85; sample represents floor material from 24 to 48 inches below coal; characteristics similar to Sample 85 except that it shows white patches of calcium carbonate and more calcium carbonate concretions.

Slaking test ..... Slakes in 11 hours.
Residues left on screens—
10 mesh 10.17%
20 mesh 0.45%
35 mesh 0.57%
65 mesh 0 52%
100 mesh 0.35%
150 mesh 0.17%
Passed 150 mesh 87.77%
Plasticity ..... Good
Molding properties ..... Good
Drying properties ..... Good
Linear drying shrinkage 9.04%
Tempering water 28.70%
Oxidation ..... Difficult, 76% oxidized in 14 hours.
Maximum safe burning temperature ..... Cone 06
Heat range ..... Cone 08 to cone 06; cracks in burning; surface pits profusely due to lime granules.
When burned at cone 06—
Burning shrinkage 4.06%
Total shrinkage 13.10%
Porosity 9.68%
Fracture ..... Dense, stony
Color ..... Pale red; scums excessively.
Possibilities ..... Not a suitable material as it is difficult to oxidize, cracks in burning, pits, and scums excessively.

JOSEPH TAYLOR COAL COMPANY, TAYLOR MINE, O'FALLON

(See figure 61)

Depth of shaft—200 feet.

Coal bed—No. 6.

Thickness of floor clay—Reported to be 7 feet.

Sample 3.—Location in mine, 2d N. off E.; sample represents floor material from 0 to 48 inches below coal; soft gray shale; contains carbonaceous matter as plant fossils and a small amount of calcium carbonate.

Slaking test ..... Slakes rapidly to a plastic mass with very little granular matter.

No screening tests made.

Plasticity ..... Very high.

Molding properties ..... A little too plastic to mold well.

Drying properties .. Warps and tends to crack; high-drying shrinkage.

Linear drying shrinkage 14.29%

Tempering water 38.20%

Oxidation ..... Difficult, 65% oxidized in 8 hours.

Maximum safe burning temperature ..... Cone 06

Heat range ..... Very short; bloats above cone 06; cracks in burning.

When burned at cone 06—

Burning shrinkage 8.28%

Total shrinkage 22.57%

Porosity 1.14%

Fracture ..... Vitreous

Color ..... Dark red; scums slightly.

Possibilities ..... Not a suitable material as it has excessive plasticity, warps and cracks in drying, is difficult to oxidize, has short heat range, and cracks in burning.

AUBURN & ALTON COAL COMPANY, AUBURN

(See figure 62)

Depth of shaft—268 feet.

Coal bed—No. 6.

Thickness of floor—Irregular, 8 feet thick at sump.

Sample 81.—Location in mine, 2,800 feet east of shaft; sample represents floor material from 2 to 23 inches below coal; light-gray sandy clay streaked with yellow; contains mica and streaks of carbon.

Slaking test ..... Action complete at end of test.

Residues left on screens—

10 mesh 5.67%

20 mesh 2.17%

35 mesh 2.64%

65 mesh 7.55%

100 mesh 11.49%

150 mesh 6.52%

Passed 150 mesh 63.96%

Plasticity ..... Fair

Molding properties ..... Good

Drying properties ..... Good
Linear drying shrinkage 4.41%
Volume drying shrinkage 13.80%
Tempering water 19.20%
Oxidation .....Complete in 4 hours.
Maximum safe burning temperature.....Above cone 5.
Heat range...Temperature not carried high enough to determine this.
When burned at cone 5—
Burning shrinkage 6.51%
Total shrinkage 10.92%
Porosity 14.88%
Fracture ..... Stony
Color .....Salmon at cone 010, brownish gray at cone 5.
Possibilities .....Common and front brick.

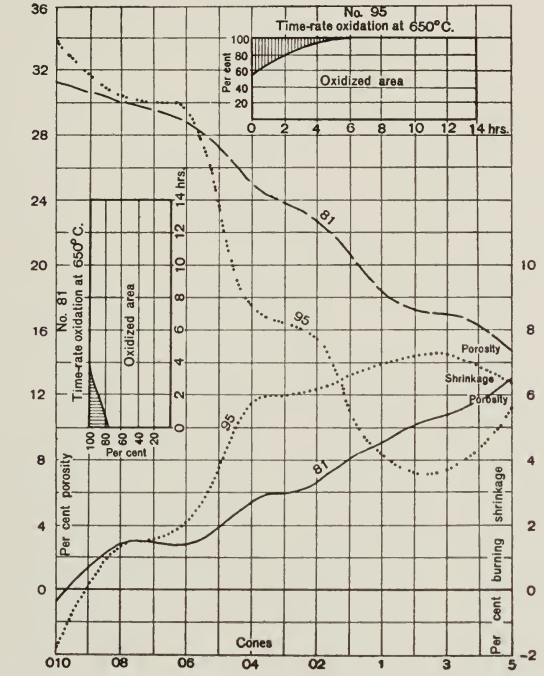


Fig. 62.—Graphic illustration of the laboratory tests of Samples 81 and 95, floor materials in the mine of Auburn & Alton Coal Company, Auburn.

Sample 95.—Location in mine, 300 feet from shaft back E. entry; sample represents 25 inches of floor material beginning a few inches below coal; sample had been wet and partly slaked; contains pyrite nodules, carbonaceous matter, sulphur, and iron sulphate.

Slaking test .....Slakes in 11 hours.
Residues left on screens—
10 mesh 0.70%
20 mesh 1.55%
35 mesh 5.09%
65 mesh 9.16%
100 mesh 5.04%
150 mesh 2.75%
Passed 150 mesh 75.71%

Plasticity	Good
Molding properties	Good
Drying properties	Good
Linear drying shrinkage	5.88%
Volume drying shrinkage	18.60%
Tempering water	23.00%
Oxidation	Complete in 6 hours.
Maximum safe burning temperature	Cone 3
Heat range	Cone 1 to cone 3.
When burned at cone 3—	
Burning shrinkage	7.23%
Total shrinkage	13.11%
Porosity	7.44%
Fracture	Stony
Color	Dark velvet-red surface, dark red fracture.
Possibilities	Common and front brick.

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